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U.S. Fish & Wildlife Service

**MONITORING AND EVALUATING VARIOUS SIZES OF
DOMESTIC-REARED RAZORBACK SUCKER
STOCKED IN THE
UPPER COLORADO AND GUNNISON RIVERS:
1995-2001**



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1995-2001**

Recovery Program Project Number 50

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*Recovery Implementation Program
for Endangered Fishes in the
Upper Colorado River Basin*

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DISCLAIMER

The opinions and interpretation of the data expressed in this report are those of the author and do not necessarily reflect the views of the Fish and Wildlife Service or the Recovery Program.

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Throughout this report, a combination of English and metric measurements are used according to their predominant usage for specific data categories and what are meaningful to many readers. English equivalents are used to identify distances within and along river drainages (river miles). Metric units are most commonly used for biological work associated with listed fishes and they were retained for this report.

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List of Key Words: razorback sucker, stocking, reintroduction, Upper Colorado River, Gunnison River, optimum size for stocking, dispersement, survival

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EXECUTIVE SUMMARY

This was an experimental stocking study aimed at further evaluating if stocking could be used as a tool to restore and re-establish razorback sucker in the Upper Colorado River Basin. The purpose of this 6-year investigation was to evaluate the survival and performance of three different sizes of domestically-propagated and reared razorback sucker following stocking in the Upper Colorado and Gunnison rivers. Specific objectives were to:

1. Determine the relationship between the size of razorback sucker stocked at 100 mm, 200 mm, and 300 mm [total length] and their subsequent survival in the wild.
2. Determine the dispersal of stocked fish of various sizes following release over time.
3. Determine habitat use of juvenile (100 mm) or sub-adult (200–300 mm) fish in the riverine environment.
4. Identify ways to reduce mortality of stocked fish.
5. Evaluate different gear for sampling juvenile and sub-adult razorback sucker that will be needed to develop a monitoring program for this species.
6. Recommend the size of razorback sucker the Recovery Program should produce in hatcheries and grow-out ponds to stock for restoring this species in the Upper Colorado and Gunnison rivers.

A total of 49,954 juvenile, sub-adult, and adult razorback sucker were stocked in both the Upper Colorado (31,531) and Gunnison (18,423) rivers in Colorado from April 1994 through October 2001. The mean total length of razorback sucker stocked during this period was 187 mm. A total of 235 razorback sucker stocked in the Upper Colorado and Gunnison rivers were either recaptured (226) or found dead (9) from sampling or during other research sampling efforts. This represented about 0.5% of all razorback sucker stocked. Of the 235 fish collected, 84 of these fish were recaptured 6 months or more following stocking.

Eighty-one family lots of razorback sucker were stocked between 1995 and 2001. Forty different family lots were represented from the 226 razorback sucker recaptured alive between 1996 and 2001. One single family lot (1992–2A), reared at Wahweap State Fish Hatchery, Utah, was recaptured more than any other lot stocked. This lot accounted for 13.1% of the 84 razorback sucker recaptured that had been at large for 6 months or more during this evaluation. This lot comprised 12.4% of the 282 razorback sucker stocked in October 1996. One of these stocked razorback sucker was recaptured 4.8 years later in the fish trap at the Redlands Dam passageway. The same family lot was stocked in the San Juan River and recapture rates from that stocking were also higher than other family lots stocked in that river system (23.2%). It is speculated that this family lot performed well following stocking because the average size at release was over 300 mm (San Juan River: mean=400 mm; Upper Colorado and Gunnison rivers: mean=343 mm).

Results from razorback sucker recaptured in the Upper Colorado and Gunnison rivers from 1997–2001 following stocking suggest that survival is related to the size of fish stocked. Larger size-classes (> 200 mm) have a higher recapture rate than razorback sucker stocked at smaller sizes. Razorback sucker stocked at sizes greater than 200 mm appear to have better short-term survival following release in the river than smaller fish stocked (e.g., < 200 mm);

recapture rates for these smaller sized fish were only about 4.8%. The highest percentage (28.6%) of fish were recaptured from the 200–249 mm class, followed by the 400–499 mm group (15.5%), and 250–299 mm group (14.2%). For razorback sucker that had been at large at least 6 months or more following stocking, the 250–499 mm size class accounted for 64.2% of the total number of stocked razorback sucker recaptured from 1997–2001. These size classes comprised only about 8.1% of the total number of razorback sucker stocked (3,549) prior to April 2001.

Dispersal following stocking was predominantly downstream from the release site. Based on recapture data, domestic-reared razorback sucker stocked between 1995 and 2001 in the Upper Colorado and Gunnison rivers exhibited downstream displacements shortly following stocking. Downstream displacement following stocking was anticipated, based on results from domestic-reared fish released in other river systems. Of the 84 recaptured razorback sucker that had been at large for 6 months and more, only four were known to have exhibited upstream movement. Three of the upstream movements were in the Gunnison River and one was in the Green River, Utah. For razorback sucker recaptured 6 months or more following stocking, the mean downstream displacement was 50.9 miles compared to the mean upstream displacement of 1.3 miles. Razorback sucker movement was significantly greater downstream (3.3 times) in the Gunnison River (mean of 73.8 miles) than in the Upper Colorado River (mean of 22.1 miles), following stocking.

Recaptured razorback sucker were more frequently collected from backwater habitats (65%) than any other habitat type, which is an important observation because most of the monitoring was with electrofishing that sampled shoreline habitats. Electrofishing was the predominant gear used to monitor stocked razorback sucker. For the most part, while different gear types were used to accomplish different objectives among various Recovery Program studies, they were not evaluated to determine which was more effective in collecting stocked razorback sucker.

Recommendations include, 1) continuing to stock domestic-raised razorback sucker in the Upper Colorado and Gunnison rivers, and at a size greater than 200 mm; 2) monitoring stocked razorback sucker following release, and at a frequency necessary to determine survival, dispersement, river-reach retention, distribution, abundance, and causes for mortality; 3) continuing to mark razorback sucker stocked in the wild with PIT tags; 4) continuing to measure individual marked razorback sucker to be stocked; 5) monitoring the subsequent reproductive contribution to the adult razorback sucker population; 6) identifying razorback sucker spawning areas; 7) conducting genetic monitoring by collecting the appropriate genetic material or sacrificing offspring from various representative family lots produced from paired mating crosses to ascertain if genetic diversity and variability are being maintained in offspring similar to that of wild stock using the current breeding strategies; 8) utilizing established culture protocols and procedures for harvesting, handling, and transporting domestic-reared razorback suckers prior to and during stocking, particularly emphasizing tempering transport water and adding salt; and 9) determining if site-acclimating domestic-reared razorback sucker by stocking fish into floodplain habitats or holding fish for possibly up to 1 week in riverine backwaters increases survival in the river.

INTRODUCTION

General

The razorback sucker (*Xyrauchen texanus*) is one of several native fishes that were formerly common and widespread throughout warm-water reaches of the Colorado River Basin, primarily in the mainstem and large tributaries from Wyoming to Mexico. Razorback sucker numbers have declined appreciably since human alteration of the aquatic environment began in the basin near the turn of the 20th century. They currently exist naturally only as a few disjunct, aging populations or scattered individuals (Minckley et al. 1991). Most investigators (e.g., Tyus et al. 1987; Osmundson and Kaeding 1989; Bestgen 1990) consider the razorback sucker to be much more rare than the endangered Colorado pikeminnow (*Ptychocheilus lucius*).

The decline of the razorback sucker is attributed to changes in physical and biotic factors leading to very low recruitment because of high mortality during the larval and juvenile life stages. Although the causes are not known, recruitment failure may be due to deterioration of water quality and/or predation on eggs, larvae, and juvenile razorback sucker by nonnative fish (Marsh and Langhorst 1988; Minckley et al. 1991; Pacey and Marsh 1998). Reduction of high spring flows has altered the natural flooding cycle, and some investigators (McAda 1977; Tyus and Karp 1989; Osmundson and Kaeding 1991) attribute lack of recruitment, in part, to the reduced availability of inundated floodplains which historically provided spawning and feeding for adults and nursery habitat for young. Because of its precarious status, the U. S. Fish and Wildlife Service (FWS) listed the razorback sucker as an endangered species (effective 22 November 1991; Federal Register, Vol. 56, No. 2105, 23 October 1991) under authority of the Endangered Species Act of 1973 (FWS 1973).

The largest extant population occurs in Lake Mohave, Arizona, but no natural recruitment to this population has been documented in recent decades and the adult population is declining (Marsh 1994) despite recent successful augmentation efforts (Mueller 1995; Marsh 1997). The largest riverine population occurs in low gradient reaches of the Green River Basin (middle Green River, Utah), with the center of distribution between the mouth of the Duchesne River to the mouth of the Yampa River (Tyus 1987; Tyus and Karp 1990; Modde et al. 1996) (Figure 1). However, abundance estimates for wild adult razorback sucker in the middle Green River, Utah, have declined substantially from 300 to 600 adults in the late-1980s and early-1990's (Modde et al. 1996) to only about 80 to 180 individuals in the late-1990s (Bestgen et al. 2002). Recruitment failure was speculated as the reason for this recent decline.

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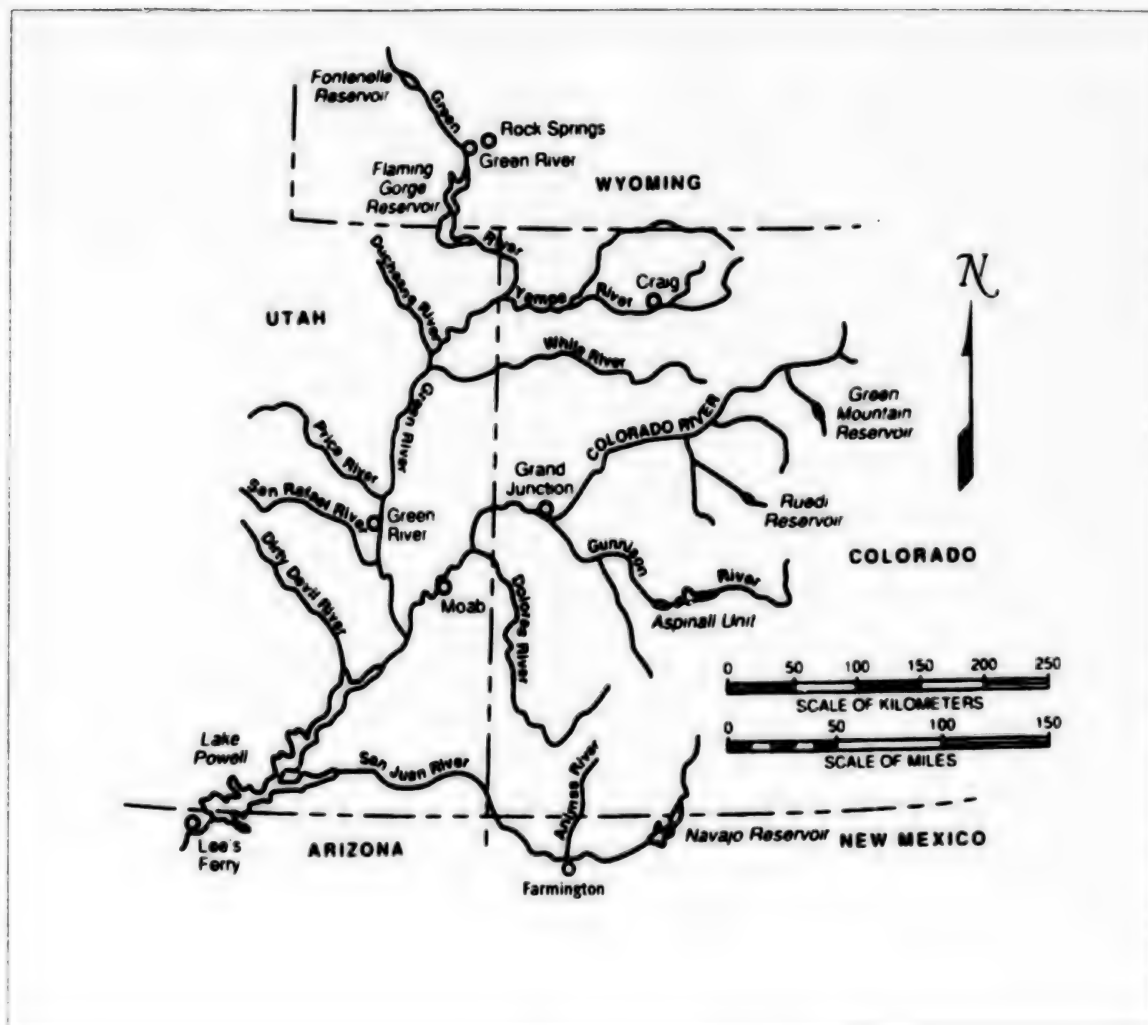


Figure 1. Geographic scope of the Upper Colorado River Basin.

Wild razorback sucker originally occupied habitat in the Upper Colorado River from about Rifle, Colorado, to the confluence with the Green River, and in the Gunnison River from approximately Delta, Colorado, downstream to the confluence with the Colorado River (Valdez et al. 1982; Holden et al. 1981; Burdick 1992; Burdick and Bonar 1997). In the Gunnison River, the last captures of wild razorback sucker were in 1981 when three adults were captured immediately downstream from Delta (Holden et al. 1981) (Figure 1). In the Upper Colorado River only a few individuals are thought to remain. Remaining wild individuals are composed exclusively of old adults. Populations of wild razorback sucker are now virtually extinct in these river reaches, and inadequate numbers exist in the wild to allow populations to be restored through natural reproduction or for natural recolonization and expansion to occur. Therefore, in the Upper Colorado and Gunnison rivers, too few adult razorback sucker now exist to maintain self-sustaining or to re-establish populations in the riverine system, largely believed to be due to persistent recruitment failure.

Although limited recruitment may have been occurring, it was not sufficient to maintain populations in either river. In the Upper Colorado River Basin, razorback sucker larvae have been collected in the Green and Colorado rivers, but juveniles are essentially absent (Gutermuth et al. 1994; Muth et al. 1998; FWS 1998). Juveniles have been reported throughout the basin (Taba et al. 1965; Modde et al. 1996; Holden et al. 1997); however, their collection is extremely rare suggesting there is little or no recruitment to old, relic populations (Minckley et al. 1991; FWS 1998).

Consequently, the Biology Committee of the Upper Colorado River Endangered Fishes Recovery Program (RP) placed a high priority on re-establishing razorback sucker in the Upper Colorado and Gunnison rivers by stocking domestically-produced and reared fish. Razorback sucker are considered a priority 1 species (Czapla 1999; Nesler et al. 2002) for augmentation and restoration efforts in Colorado (Nesler 2001) and Utah (Hudson 2001) due to the presence of, but declining trend of wild populations due to inadequate recruitment.

There are five primary components to achieving recovery of razorback sucker and the other endangered fish species in the RP. One of these is propagation, stocking, and genetics management. Thus, propagation and stocking is considered one of the primary approaches to establishing self-sustaining populations. An effective stocking program for establishing razorback sucker populations would require that stocked fish: 1) remain in the system and successfully adapt to the habitat into which they are stocked, 2) ultimately survive to adulthood, mature, and contribute offspring that restore or increase the size of an existing population, and 3) present an acceptable risk to other native aquatic species and communities. Stocking is believed to provide

an effective and timely means to restore wild razorback sucker populations in river reaches designated within the Genetic Management Plan (Wydoski 1995) and essentially would accomplish three objectives: 1) restore populations of razorback sucker to unoccupied river reaches, 2) augment very small populations in occupied reaches, and 3) establish a minimum viable population of at least three adult age groups (5 to 7) at the population abundance criteria developed within the recovery goals for the razorback sucker (FWS 2002).

Summary of Razorback Sucker Experimental and Augmentation Stocking Plans

The RPs for the Upper Colorado River and the San Juan River basins each required that a stocking plan be approved before any domestic-reared fish could be stocked into the wild. Experimental stocking and augmentation plans for the razorback sucker were initially developed for the Upper Colorado and Gunnison rivers in Colorado (Burdick 1992; Burdick et al. 1995) and the San Juan River in New Mexico and Utah (Ryden and Pfeifer 1994). Burdick (1992) and Ryden and Pfeifer (1994) addressed the essential elements for an experimental stocking program to obtain fundamental information on the ecology of razorback sucker to determine the feasibility and utility of augmentation or restoration stocking as a recovery tool. These were conceptual plans that also discussed the rationale and justification for experimental stocking, the genetic and ecological risks associated with experimental stocking, justification for selection of stocking areas, and the protocol and criteria to investigate the relation between size at stocking and their subsequent survival in the wild. The plans also outlined research efforts and general procedures to monitor stocked fish and evaluate a stocking program.

Once it was demonstrated or believed that experimentally stocked fish would survive and suitable habitat existed to support sub-adult and adult fish, additional plans evolved to identify the number and size of fish needed to evaluate the relation between survival to size at release, and the number of adult fish needed per river reach to achieve recovery. Modde et al. (1996) discussed an augmentation plan for razorback sucker in the Upper Colorado River Basin coincident with environmental enhancement. Individual plans were developed for the San Juan (Ryden 1997) and Upper Colorado and Gunnison rivers (Burdick et al. 1995) and identified additional monitoring for various sizes of stocked razorback sucker for up to 5 to 6 years. A restoration plan to augment present razorback sucker populations was developed for the middle Green River in Utah (Wydoski 1996).

The States of Colorado (Nesler 1998) and Utah (Hudson et al. 1999) later developed their own individual stocking plans for each of the four mainstem endangered fishes that refined the

aforementioned experimental stocking plans. These plans were intended for initiating a comprehensive restoration stocking program aimed at establishing naturally sustaining populations. They were also more specific than earlier experimental stocking plans and met the goals and objectives set forth by the Genetics Management Plan (Wydoski 1995; Czapla 1999) and the Endangered Fish Interim Management Objectives (IMO's) for the RP. These stocking plans provided direction and rationale for initiating and conducting propagation, augmentation, and restoration for razorback sucker in select rivers within the Upper Colorado River Basin in each of the respective states. The plans also included priorities among the four different endangered fish species and river reaches, genetic risk assessment, size and number of fish to stock over a period of 5 to 9 years, time of year to stock for best survival, and criteria for contribution to recovery success as well as expectations and limitations.

Both Colorado (Nesler 2001) and Utah (Hudson 2001) revised their former plans to be consistent with population abundance criteria developed within the recovery goals for razorback sucker (FWS 2002) and the other three endangered fish species in the Upper Colorado River Basin. These two revised plans identified stocking targets over the next 8 to 10 years based on the criteria in the recovery goals and integrated survivorship estimates (see Ryden 2001). These criteria replaced the previous objectives identified in each of the two plans based on the IMO's. The primary goal identified in these stocking plans was to establish at least one to three minimum viable razorback sucker populations (5,800 adult fish from ages 5 to 7) in the Upper Colorado and Gunnison rivers in Colorado to complement the existing razorback sucker populations in the middle and lower reaches of the Green River in Utah. Utah's plan identified establishing one minimum viable population in the Green River (5,800 fish of a multiple age-class structure). These revised stocking plans called for the production of fewer, but larger razorback sucker than earlier versions, and considerably less fish than requested for this evaluation. The Colorado stocking plan for razorback sucker called for producing a 300-mm, domestic-reared razorback by the age of 2 + before stocking into the mainstem Colorado and Gunnison rivers in Colorado.

In November 2002, an integrated stocking plan was formulated that served as an addendum to the previous stocking plans developed by Colorado (Nesler 2001) and Utah (Hudson 2001). The integrated plan (Nesler et al. 2002) unified the separate State stocking plans and included the San Juan River subbasin; the intent was to add consistency throughout the Upper Colorado River Basin. For razorback sucker, the number of Age 2 + fish to be stocked annually in the Upper Colorado and Gunnison rivers was decreased from 16,440 to 9,930 due to the increase of multiple age groups from 3 to 4. This plan recommends maintaining four adult age classes, which would require stocking razorback sucker for 6 years. Unchanged was the survival

rate of adult razorback sucker (0.70) and the recovery goal abundance buffer of 30%.

Domestic-reared razorback sucker will be used to establish new populations in the Upper Colorado and Gunnison rivers or augment existing populations (e.g., Green River system). Stocking domestic-reared razorback sucker will continue until more fish recruit to the adult population through natural reproduction in the wild. As more razorback sucker recruit to the adult population by natural reproduction in the wild, stocking hatchery-propagated fish in the wild should be reduced. For razorback sucker populations to be self-sustaining, adult fish must reproduce and recruitment of young fish into the adult population must occur at a rate to maintain the population at a minimum of 5,800 adults (FWS 2002). At this point, stocking razorback sucker in the wild should be discontinued.

The RP has sufficient facilities and associated grow-out ponds to meet the demands of the integrated stocking plans (Czapla 2002). The production of razorback sucker to meet the number identified in the Utah stocking plan requires 2.0 ha (5.0 acres) of hatchery ponds and 4.2 ha (10.4 acres) of leased grow-out ponds. The production of razorback sucker to meet the numbers in the Colorado stocking plan require 7.3 ha (18.1 acres) of leased grow-out ponds. Forty hectares (98 acres) of grow-out ponds are available for use in the Grand Valley near Grand Junction, Colorado (Czapla 2002).

Purpose and Objectives

The purpose of this study was to evaluate the survival and performance of three different sizes of domestically-propagated and reared razorback sucker following stocking in the Upper Colorado and Gunnison rivers. Domestically-propagated and reared fish included fish raised in hatcheries and grow-out ponds. This was an experimental stocking program aimed at predicting the potential success of subsequent supplemental stockings. Experimental stocking is a legitimate tool that can be used as an action preliminary to the decision of whether restoration or augmentation stocking has a chance of success (Williamson 2001). Experimental stocking can help define restoration stocking as a preferred production strategy.

The study goals were to:

1. Evaluate the relation between survival of razorback sucker and size at release into the river, either by stocking captive-reared fish or by producing fish in enhanced flooded bottomland habitats,
2. Re-introduce razorback sucker in the Gunnison River that would result in 10 adult fish per river mile in suitable habitat with a target of re-establishing a population of about

600 adult razorback sucker from Austin, Colorado, downstream 68 river miles to the confluence with the Colorado River near Grand Junction.

Note: goal number two was not achieved because an insufficient number of stocked razorback sucker were recaptured to provide a reliable population estimate.

Specific objectives of the study were to:

1. Determine the relationship between the size of razorback sucker stocked at 100 mm, 200 mm, and 300 mm total length [TL] and their subsequent survival in the wild. (Note: 100-mm fish was defined as the median of 100-mm (e.g., 75–149 mm); 200 mm (e.g., 150–249 mm); and 300 mm (e.g., 250–350 mm).
2. Determine the dispersal of stocked fish of various sizes following release over time.
3. Determine habitat use of juvenile (100 mm) or sub-adult (200–300 mm) fish in the riverine environment.
4. Identify ways to reduce mortality of stocked fish.
5. Evaluate different gear for sampling juvenile and sub-adult razorback sucker that will be needed to develop a monitoring program for this species.
6. Recommend the size of razorback sucker the Recovery Program should produce in hatcheries and grow-out ponds to stock for restoring this species in the Upper Colorado and Gunnison rivers.

Study Area

The study area monitored for stocked razorback sucker included the Upper Colorado River from Rifle (river mile [RM] 240.7) downstream to Beavertail boat landing (RM 195.7), Price-Stubb Dam (RM 187.6) to the Grand Valley Diversion Dam at Palisade, Colorado, (RM 185.4), and Corn Lake (RM 177.4) to Westwater Ranger Station, Utah (RM 128). On the Gunnison River, the area included the nearly 57 river miles from Hartland Diversion Dam (RM 60) to immediately upstream from the Redlands Diversion Dam (RM 3.9) and the 2.3-mile reach between the Redlands Dam to the confluence with the Colorado River (Figure 2). The physical characteristics of individual river reaches (strata) were previously described for the Upper Colorado River from Rifle to Westwater by Valdez et al. (1982) and Pitlick and Cress (2000), and by Burdick (1991) for the Gunnison River from Delta downstream to the confluence with the Colorado River.

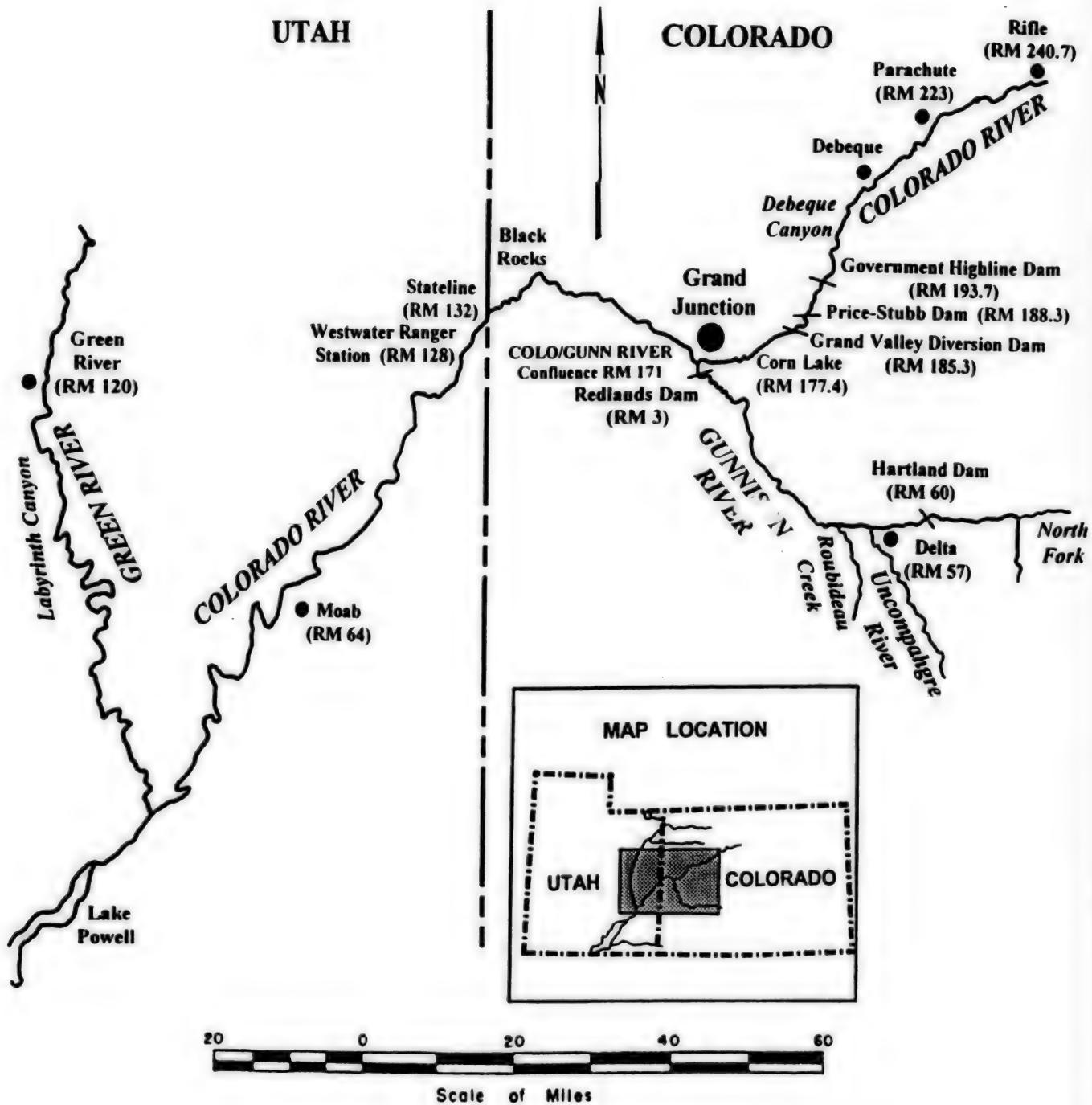


Figure 2. General area of domestic-reared razorback sucker releases in the Upper Colorado and Gunnison rivers, 1994–2001, and the area monitored where stocked razorback sucker were subsequently recaptured in the Upper Colorado, Gunnison, and Green rivers, 1996–2001.

METHODS

Fish Propagation and Stocking

The Genetics Management Plan (Williamson and Wydoski 1994; Wydoski 1995; Czapla 1999) identified the need for 25 family lots for razorback sucker propagation efforts. Ultimately, razorback sucker produced from such propagation efforts would be stocked in two stream reaches in the Upper Colorado River (Rifle to Debeque Canyon [RM 240–203] and Palisade to Westwater [RM 185–128]) and one river reach in the Gunnison River (Hartland Diversion Dam to Redlands Diversion Dam [RM 60–3]). However, in the Upper Colorado and Gunnison rivers, numbers of wild razorback sucker were insufficient for collection and use in a 5 X 5 di-allele breeding matrix to even attempt to develop broodstock. Additionally, razorback sucker located in Etter Pond near Debeque, Colorado, were determined to be dominated by potential siblings from a very small number of parents, and potentially hybridized with flannelmouth sucker. Therefore, mating crosses between any two individual fish from Etter's Pond were determined to be genetically unacceptable due to the risk of inbreeding. However, since there was an insufficient number of razorback sucker broodstock, managers decided that a limited number of Etter Pond razorback sucker could be used if they were crossed only with wild Colorado River broodfish (personal communication, Mike C. Baker, FWS, Grand Junction, Colorado). Therefore, the RP approved development of a "blended stock" of razorback sucker to serve as the broodstock for the Upper Colorado and Gunnison rivers.

A captive breeding strategy for these fish was described in Burdick et al. (1995) which followed the RP's Genetics Management Guidelines (Williamson and Wydoski 1994; Wydoski 1995). Fifteen wild adult razorback sucker obtained from four different sources in the Upper Colorado River Basin were used to produce offspring for stocking and for future broodstock (Appendix; Table A.1.). These fish were collected from the Colorado River arm of Lake Powell (4 fish), the Upper Colorado River near Grand Junction (4 fish), the San Juan River arm of Lake Powell (4 fish), and Etter Pond (3 fish). All adult fish used in the breeding scheme were PIT tagged to identify pedigree of offspring produced. The initial breeding matrix used is provided in Appendix; Table A.2.

Most of the razorback sucker stocked in the Upper Colorado and Gunnison rivers were produced from wild and first generation (F_1), domestic-reared broodstock. The progeny were obtained from paired matings of these captive wild fish, of wild and captive domestic-propagated broodfish (F_1), and of captive (F_1) broodfish. Between 1992 and 2001, eight year classes comprising eighty-one different family lots of razorback sucker were produced (Appendix; Table

A.1.). Fish were domestically-propagated and reared at different sources and sites. This included indoor tanks at Ouray National Fish Hatchery (NFH), Utah; the 24-Rd Hatchery operated by the FWS at Grand Junction; Valley City NFH, North Dakota; Bellvue State Fish Hatchery (SFH), Ft. Collins, Colorado; outdoor, earthen ponds at Horsethief State Wildlife Area (SWA), near Fruita, Colorado; and grow-out ponds at Wahweap SFH, Big Water, Utah, and in the Grand Valley of western Colorado near Grand Junction.

Each family lot was maintained separately until they were large enough to be PIT-tagged which was about 100 mm long. All fish produced from these controlled matings and eventually stocked into the rivers were PIT tagged so that their genetic background could be traced. Moreover, fish marked with PIT tags could provide specific information on stocking date and location, as well as multiple recaptures.

Between October 1995 and October 2001, domestic-reared razorback sucker were stocked in the Upper Colorado and Gunnison rivers at various sizes that ranged from 75–586 mm (3–23 inches). In 1994, 45 adult razorback sucker were collected from Etter Pond, marked with PIT tags, and surgically implanted with radio transmitters. Twenty of these fish were translocated to the Upper Colorado River (mean TL=502 mm; range=451–534 mm) near Debeque and 25 were translocated to the Gunnison River (mean TL=492 mm; range=455–536 mm) near Delta (Burdick and Bonar 1997). During 1999 and 2001, “excess” broodfish became available at the Horsethief SWA ponds. These additional fish were no longer needed because sufficient numbers of these year classes were available for broodfish and refugia. Consequently, these excess broodfish were stocked in the Gunnison River during 1999 and 2001 (see Appendix; Table C.5. and C.7. for length statistics).

Razorback sucker stocked into grow-out ponds were later harvested with trap nets of various mesh sizes. Most razorback sucker harvested from grow-out ponds and those from the 24-Rd Hatchery were measured (TL, mm). In some instances when there were large numbers of fish to stock from the 24-Rd Hatchery during one day that had already been tagged, only a representative sub-sample of fish were measured. About every fourth razorback sucker processed was weighed. Lengths and weights were taken from only 30 representative individuals from the 1992 year-class sub-adult razorback sucker that were reared at Wahweap SFH and later stocked in the fall of 1997. After being PIT tagged, fish were transported from hatchery facilities or grow-out ponds to river stocking sites using stocking trucks equipped with 250-gallon aerated stock tanks. Upon arrival at stocking sites, razorback sucker were placed directly in riverine habitats with the lowest possible water velocities which were usually shallow side channels or

backwaters. Stocked fish were not site-acclimated, i.e., they were not tempered to river temperatures nor were they held in quiet riverine habitats behind barrier nets (see Mueller and Foster 1999). In the Gunnison River, razorback sucker were stocked at two sites. In 1995, fish were stocked at RM 59.3. All other razorback sucker were subsequently stocked at RM 57.0. In the Upper Colorado River, fish were stocked at three sites. Two sites were near Parachute, Colorado (RM 226.5 and 229.9), and the other in the 15-mile reach near Corn Lake (RM 177.4).

Fish Sampling

Electrofishing from aluminum jon boats and rubber rafts was the primary means used to sample for stocked razorback sucker during scheduled monitoring trips from 1996–2001. Whenever feasible, two electrofishing craft were used simultaneously and proceeded sampling downstream. Oar-powered electrofishing rafts mainly sampled shoreline habitats. Electrofishing from motorized jon boats sampled all possible habitats which included shorelines, backwaters, and eddies. Seines (6-mm bar mesh, 9-m long X 1.8-m deep) were used to sample backwater and slow-velocity habitats in the Gunnison River from RM 59.3 to RM 4.8 for stocked razorback sucker only during the fall of 1995. Sampling for stocked razorback sucker generally was conducted following spring runoff and occurred from mid-July through mid-October.

During October 1996, the river reach from Confluence Park (RM 57) to Roubideau Creek (RM 50.3) was sampled on three different occasions (Appendix B). Some of this work was associated with the northern pike removal project in the Gunnison River (McAda 1997 [RP No. 58]). The reaches from Roubideau Creek to Bridgeport (RM 29.3) were sampled at least once with an aluminum jon boat. During 1997, only one rotation was conducted during late-July and early-August on the Gunnison River between Confluence Park and Redlands Diversion Dam (RM 3.9). During 1998, all Gunnison River reaches were sampled twice except for the 10.8-mile reach from Whitewater (RM 14.7) to Redlands Diversion Dam (RM 3.9). During 1999, 2000, and 2001, the Gunnison River from Confluence Park to Redlands Diversion Dam was sampled twice, two electrofishing craft were used for each trip. The 2.3-mile reach of the Lower Gunnison River from the Redlands Diversion Dam to the confluence with the Colorado River was also sampled during 2001.

Since juvenile razorback sucker were stocked for the first time in the Upper Colorado River in 1999, the reach between Rifle to Beavertail boat landing was sampled in 2000. In 2001, the same reach was again sampled in the Upper Colorado River along with reaches from Price-

Stubb Dam to the Grand Valley Irrigation Dam and Corn Lake to Westwater Ranger Station. Some warmwater reaches in the Upper Colorado River in western Colorado (e.g., Government Highline Dam to Price-Stubb Dam) and eastern Utah (e.g., Westwater Ranger Station to Westwater Wash, RMs 128–124.8) were not sampled, whereas other reaches were sampled more than others (e.g., 15- and 18-mile reaches). The river miles and dates sampled from 1995–2001 and the actual electrofishing and seining effort expended sampling the Upper Colorado and Gunnison rivers are provided in Appendix; Table B.1.

Other ongoing, short-term RP projects also reported incidental recaptures of stocked razorback sucker from 1996–2001. Stocked razorback sucker were collected in the fish trap at the Redlands Diversion Dam passageway (Burdick 2001; Burdick 2002(c) [No. C-4b]), from irrigation canals (Martinez 2001, 2002 [No. CAP 18/19]) and from various riverine and off-channel floodplain habitats with seines (Trammel et al. 2002 [No. 87b]; Meisner and Hudson 2001 [No. 87a]), trammel nets (Osmundson 2002 [No. 22-A-2]), electrofishing (Osmundson 2003 [No. 89]); Burdick 2002(a) [No. 105]), and trap nets (Burdick 2002(b) [No. C-6-GP]) during other approved RP investigations. Recaptures of stocked razorback sucker were also reported in the Colorado River in Colorado (personal communication, Rick Anderson, Colorado Division of Wildlife [CDOW]), in the Colorado River in Utah (personal communication, Steve Meisner, Utah Division of Wildlife Resources [UDWR]) and in the Green River in Utah (personal communication, Peter Cavalli, UDWR).

At recapture, all razorback sucker were checked for the presence of a PIT tag, weighed (g), and measured (TL). Other data recorded were recapture location (river and RM) and date. In some instances, the PIT tag of some recaptured razorback sucker was not recorded because investigators did not have a PIT tag reader/scanner available. Return rates of stocked razorback sucker were determined from recaptured fish. Only razorback sucker that had been at large for at least 6 months following stocking were used to determine return rates and report habitat of recaptured fish. It was believed that fish that survived the first 6 months following stocking had likely adapted to riverine conditions, and it was further assumed that they were likely to continue to survive. This time period was selected by the author. None of the domestic-reared razorback sucker stocked from 1995 to 2001 were implanted with radio transmitters. Displacement was reported as upstream and downstream displacement and was defined as the respective distance between the release site and recapture point.

RESULTS AND DISCUSSION

In lieu of the traditional "Results and Discussion" section, a separate chapter was devoted to discussing field data collected from 1996–2001 related to each of the objectives previously identified. A separate section was devoted to annual stockings of razorback sucker.

Stocking of Razorback Sucker

Rationale and Strategy

Initially, three different length groups (100-, 200-, 300-mm) of razorback sucker were to be stocked in this study. In some instances, fish smaller than 100 mm were PIT tagged and stocked (e.g., the fall 1995 stocking). Likewise, fish larger than 300 mm were stocked (e.g., excess broodfish and Wahweap-reared fish). Furthermore, it simply was not realistic to expect to produce enough fish of identical length within each of these three size categories because of the variable growth that occurred among rearing locations and within environments (e.g., grow-out ponds) and family lots. Therefore, many of the harvested fish that were eventually stocked overlapped in length among these three length groups.

Producing and eventually stocking an equal number of razorback sucker among family lots within year classes was not always feasible. Whenever possible, an equal number of razorback sucker from each family produced from a year-class was stocked. Additionally, when possible, a 50:50 ratio (e.g., equal number) from each family lot was stocked in the Upper Colorado River and Gunnison River.

The small-fish group was the smallest fish that could be safely PIT tagged; the large-fish group reflected the largest fish that could be expected to be produced in one year. The different size classes were believed to allow for an assessment of whether survival was related to fish size. A ratio was used to divide fish into size groups equally among family lots based on the assumption that small fish would exhibit higher mortality. To produce the three groups for stocking, a 75:20:5 ratio was used. Biologists believed that these ratios allocated captive-reared fish based on the expectation of survival in the wild, and it was believed that they represented reasonable estimates. It was further assumed that smaller fish would not be expected to survive as well as larger fish and they would be more difficult to collect during followup monitoring efforts. The projected number of razorback sucker needed to evaluate the relation between survival and size at release by size group and river location for 1996–2000 was developed from this ratio (Table 1). Initially, it was acknowledged that the size classes and number projected

Table 1. Number of fish by size group projected to evaluate the relation between survival of razorback sucker and size at release into the river, 1995 through 2001, and actual numbers of razorback sucker stocked, 1994 through 2001, in the Upper Colorado and Gunnison rivers, Colorado. (see Appendix; Tables C.1.–C.7. for size ranges of razorback sucker stocked by year).

Year Stocked	Stocking Location	Approximate Mean Size of Fish	Number of Fish ^a	Actual Number of Fish Stocked
1994	Gunnison River	450–550-mm	---	25
	Colorado River	450–550-mm	---	20
1995	Gunnison River near Delta	^b 100–199mm	^c 10,000	316
		200–299mm	2,500	
		300-mm	600	
1996 & 1997	Gunnison River near Delta	100–199mm	10,000	3,441
		200–299mm	2,500	
		+ 300-mm	600	
1998 ^d	Gunnison River near Delta	100–199-mm	20,000	158
		200–299-mm	5,000	307
		+ 300-mm	1,200	143
1999	Gunnison River near Delta	100–199mm	30,000	2,048
		200–299mm	7,500	688
		+ 300-mm	1,800	36
1999	Colorado River near Parachute	100–199mm	30,000	3,075
		200–299mm	7,500	418
		300–399mm	1,800	5
2000	Gunnison River near Delta	100–199mm	40,000	3,785
		200–299mm	10,000	2,761
		+ 300-mm	2,400	41
2000	Colorado River near Parachute & 15-Mile Reach	100–199mm	40,000	19,141
		200–299mm	10,000	6,290
		+ 300-mm	2,400	79
2001	Gunnison River near Delta	100–199-mm	40,000	203
		200–299-mm	10,000	3,113
		300-mm	2,400	785
2001	Colorado River near Parachute & 15-Mile Reach	100–199-mm	40,000	137
		200–299-mm	10,000	1,784
		+ 300-mm	2,400	232

^a Number of fish adjusted depending upon the number of fish produced from paired matings, survival to stocking, and available rearing space

^b Minimum size of razorback sucker that can be safely PIT tagged

^c Numbers determined from a 75:20:5 ratio

^d Additional propagation facilities available in FY98 to allow for increased production of young fish

could not be closely adhered to because the number of broodfish and rearing facilities were limited. As more captive razorback sucker matured more fish would be available for spawning and therefore more progeny would be produced. As additional facilities and grow-out ponds became available, the increased space would provide more flexibility and allow family lots and year classes to be divided up and reared in different locations and under different conditions to allow differential growth. It was speculated that in 1996 and 1997, the number of fish available for stocking would fall well short of the number projected for stocking. However, it was believed that by 1998, additional rearing facilities and space would become available and more broodfish would be available to produce more young fish. Therefore, the projected number of fish to be stocked in both the Upper Colorado and Gunnison rivers in 1998 and subsequent years was increased.

As more information was obtained on the return rate of stocked fish, study direction changed in 2001. Because of this, the size of razorback sucker to be produced and stocked was adapted. Preliminary results from the recapture of stocked razorback sucker from this and similar ongoing monitoring programs in the San Juan River indicated that return of razorback sucker stocked at lengths less than 200 mm was low. Stocking razorback sucker smaller than 200 mm may be futile because it was assumed that their post-stocking performance (i.e., survival) in the wild was poor. In light of these data, in 2001, managers made the decision to stock only those razorback sucker harvested from grow-out ponds that were 200 mm or larger into the Upper Colorado and Gunnison rivers. Razorback sucker that were less than 200 mm were returned to grow-out ponds to grow larger. Thus, the plan to stock the number and sizes of razorback sucker originally recommended for 2000 and 2001 into the Upper Colorado and Gunnison rivers (see Table 1) was abandoned. Another reason for the discontinuance was that there was a facility limitation. In other words, there simply was not enough grow-out pond acreage at the time to produce the numbers and sizes of razorback sucker recommended to be stocked annually in both the Upper Colorado and Gunnison rivers.

General

Domestic-produced and reared razorback sucker were stocked in the Gunnison River starting in the fall of 1995 and continued through the fall of 2001. Eighty-one family lots of razorback sucker were stocked during this period. A total of 18,395 juvenile, sub-adult, and adult razorback sucker were stocked in the Gunnison River during this period. Twenty-five fish captured from Etter Pond were re-located and stocked in the Gunnison River in April 1994 (21)

and September 1995 (4) (Appendix; Table C.1.; Appendix; Figure C.1.; Burdick and Bonar 1997). Stocking of domestic-reared razorback sucker in the Upper Colorado River did not begin until the fall of 1999 but continued through October 2001. A total of 31,511 juvenile and adult razorback sucker were stocked in the Upper Colorado River in Colorado during this 3-year period. Twenty fish captured from Etter Pond were re-located and stocked in the Upper Colorado River in April 1994 (Appendix; Table C.1.; Appendix; Figure C.1.; Burdick and Bonar 1997). The total number of razorback sucker stocked in both rivers from April 1994 through October 2001 was 49,954. The mean TL of razorback sucker stocked during this period was 187 mm (SD=60.3; range: 75–586 mm, N=42,023; Figure 3; Appendix; Table C.8.). Fifty-nine percent of the razorback sucker stocked during this period were between 100 and 199 mm and 35% were between 200 and 299 mm. Only 4.1% of the fish were between 300 and 399 mm and about 0.5 percent were greater than 400 mm (Appendix; Table C.8.). Razorback sucker were predominantly stocked during late-summer and fall (89.2% or 44,347 fish).

1995–2001

For razorback sucker stocked during each of these 7 years, the following information is provided in tabular form (Appendix; Tables C.1–C.7.): number and size (TL, mm) of fish stocked, source and date stocked, stocking location (river and RM), year-class stocked, and the number of family lots stocked. Accompanying figures (Appendix; Figures C.1–C.7.) of razorback sucker stocked by 25-mm length groups, by river, and by year are also provided.

Three hundred sixteen (100–150 mm), pond-reared razorback sucker were stocked on 13 October 1995 at RM 59.3 in the Gunnison River near Delta (Appendix; Table C.1.; Figure C.2.). In 1996, 282, 280–410 mm fish were stocked on 4 October at RM 57 in the Gunnison River (Appendix; Table C.2.; Figure C.2.). These fish originated from Wahweap SFH. In 1997, 3,372 juvenile and adult fish (125–380 mm) were stocked in the Gunnison River on nine different dates between 12 September and 14 October from three different sources: 24-Rd Hatchery, Clymer Pond, and Wahweap SFH (Appendix; Table C.3.; Figure C.3.). In 1998, only 608 (75–493 mm) razorback sucker were stocked in the Gunnison River (Appendix; Table C.4.; Figure C.4.). During May 1999, 30 excess F₁ broodfish held in ponds at Horsethief SWA, were stocked in the Gunnison River. An additional 2,742 juvenile razorback sucker were stocked on eight different dates from three different sources between 3 August and 4 November. Three thousand, four hundred ninety eight juvenile razorback sucker from four different sources were released on five different dates between 20 September and 29 October 1999 in the Upper Colorado River

upstream from Parachute. This marked the first juvenile razorback sucker stocked in this stream reach (Appendix; Table C.5; Figure C.5.).

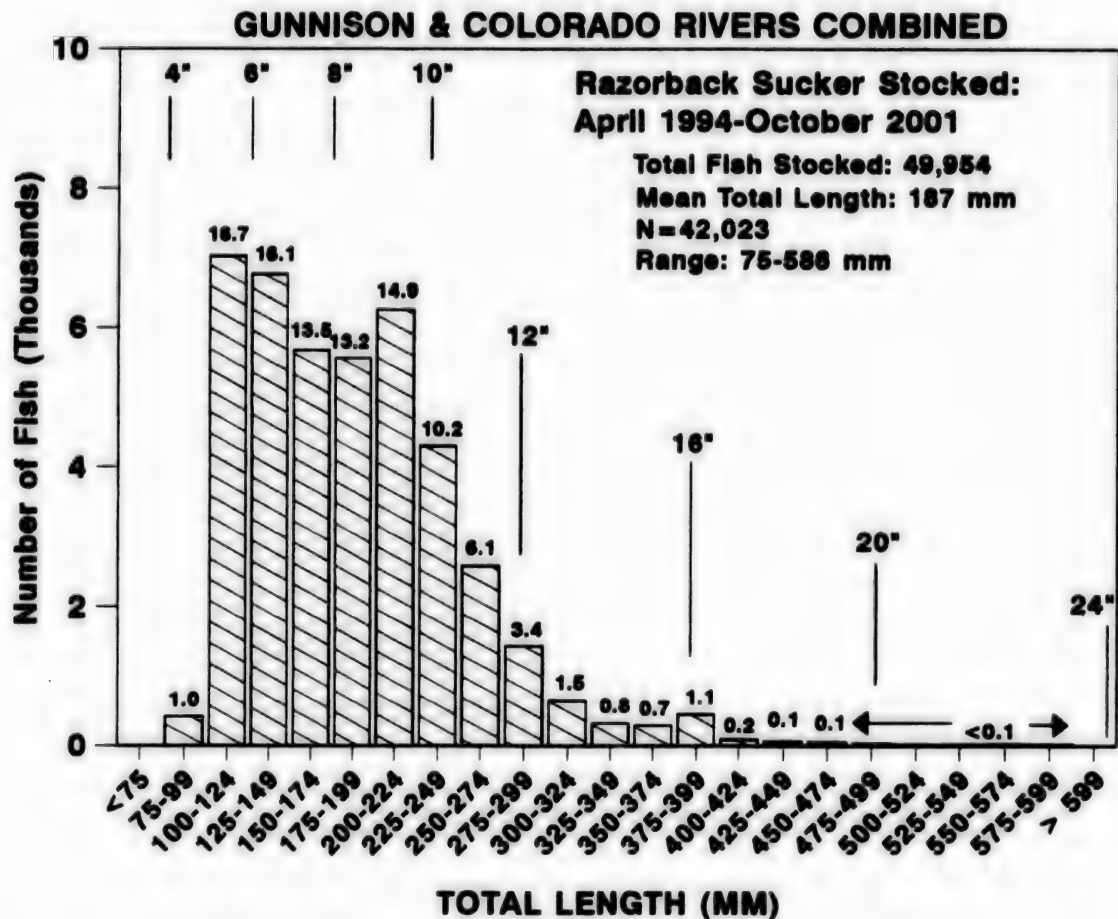


Figure 3. Length-frequency distribution of razorback sucker stocked into the Gunnison and Upper Colorado rivers between April 1994 and October 2001. Note: numbers above the bars represent percent. Note: the total number of razorback sucker stocked and "N" do not coincide because, in some instances, only a sub-sample of fish stocked on a particular day were measured. Therefore, not all fish stocked were measured.

In 2000, juvenile razorback sucker were harvested from 14 different sources, one of these being the 24-Rd Hatchery (Appendix; Table C.6.). Sixty-one percent of the fish stocked into the Upper Colorado and Gunnison rivers were reared at the 24-Rd Hatchery. The other 13 sites were grow-out ponds in the Grand Valley near Grand Junction. A total of 32,446 juvenile razorback

sucker were stocked into the Upper Colorado (25,859 fish) and Gunnison (6,587 fish) rivers. This marked the highest number of captive-reared razorback sucker stocked in one year between 1995 and 2001. Fish were stocked in the Gunnison River between mid-August and early-November; in the Upper Colorado River fish were stocked in mid-April and again between mid-August and late-November. Overall mean TL of razorback sucker stocked in 2000 was 163 mm (SD=50.3; range=77–345 mm; N=26,245; Appendix; Figure C.6.). Seventy-one percent of the fish harvested and stocked were between 100 and 199 mm and 32% were between 110–130 mm. Twenty-two percent of the fish were between 200 and 299 mm and only 0.4% were greater than 300 mm (Appendix; Figure C.6.). Two different year classes, 1998 and 1999, were harvested from 29-Rd Pond in 2000. The modal length class for the 1998 and 1999 year-classes were 240–249 mm and 120–129 mm, respectively.

In 2001, 6,255 razorback sucker were stocked in the Upper Colorado River (2,154 fish) between mid-May and mid-October and in the Gunnison River (4,101 fish) from early-April through mid-October (Appendix; Table C.7.). Overall, mean TL of fish stocked was 255 mm (SD=52.3; range=112–586 mm; Appendix; Figure C.7.). Five and one-half percent of fish harvested and stocked were between 100 and 199 mm, 79% were between 200 and 299 mm, 13.7% were between 300 and 399 mm, 1.6% were between 400 and 499 mm, and 0.2% were between 500 and 599 mm. Juvenile razorback sucker were harvested and stocked from 20 different grow-out ponds in the Grand Valley and the 24-Rd Hatchery. Ninety-nine F₁ excess broodfish were also stocked in the Gunnison River during 2001.

CHAPTER 1: Size of Fish Stocked Versus the Number Recaptured

Objective 1: determine the relationship between the size of razorback sucker stocked at 100-mm, 200-mm, and 300-mm (TL) and the number recaptured [return rate] in the wild.

Total Number Recaptured

A total of 235 razorback sucker stocked in the Upper Colorado and Gunnison rivers were either recaptured (226) or found dead (9) from sampling or during other research sampling efforts. This represented about a 0.5% return rate of all razorback sucker stocked (49,954) from April 1994 through October 2001 in these two rivers. The number of all razorback sucker recaptured alive by year was: 1996: 7; 1997: 17; 1998: 14; 1999: 21; 2000: 114; and 2001: 53. Of the 235 fish collected, 84 of these fish were recaptured 6 months or more following stocking.

The number of razorback sucker recaptured alive by year that had been at large for 6 months or more following stocking was: 1996: 0; 1997: 2; 1998: 10; 1999: 7; 2000: 30; and 2001: 35 (Appendix; Table D.1.). Multiple recaptures of some stocked fish were recorded. Five individual razorback sucker were recaptured in two different years following being stocked. One of these razorback sucker was caught three different times following stocking (twice in 2000 and once in 2001).

Nine razorback sucker were positively sighted but not netted, three in 1996, four in 1997, and one each in 1998 and 2000. None of the 316, 100–150 mm juvenile razorback sucker stocked in 1995 were recaptured. Only 13 of the 2,287 juvenile razorback sucker stocked in the Gunnison River during August, September, October, and November 1999 were subsequently collected alive during followup monitoring during intensive, ongoing sampling programs in the Upper Colorado or Gunnison rivers. During August, September, and October 1999 and 2000, an additional 95 razorback sucker were found dead or dying on the trash grates at the Redlands Dam passageway. Some of these fish were found on the grates only 1 d after being stocked nearly 53 miles upstream, suggesting that they were dead or in poor condition at the time of stocking. These fish were not included with the 235 razorback sucker that were collected alive or dead.

Year-Classes & Family Lots

Recaptured razorback sucker were represented from various family lots from different year-classes produced. Forty different family lots were represented from the 226 razorback sucker recaptured alive between 1996 and 2001 (Appendix; Table E.1.). The following year-classes and number of family lots from each year-class (in parenthesis) comprised the fish recaptured alive during this 6-year period: 1991 Green River (1), 1992 (5), 1995 (10), 1996 (7), 1997 (1), 1998 (3), 1999 (12), and 2000 (1). Some of the razorback sucker recaptured either did not have a PIT tag when caught, a PIT tag reader/scanner unit was not available or was inoperative to check for a PIT tag, or the biologist(s) failed to scan or record the PIT tag. Therefore, no data were obtained from these fish regarding size at release, where and when they were stocked, or family-lot origin. The number and size of razorback sucker stocked from each family lot and the number recaptured from each lot is provided in Appendix; Table E.1.

While the actual number of razorback sucker recaptured in some lots appeared to be greater than others, the percent recovered in relation to the number stocked was quite small. For instance, 38 razorback sucker were from family lot 9911, but the percent recovered was only 0.5% of the total stocked (7,782). Three percent of family lot 9803 was recovered (12 of 558

fish). Fifty fish (0.8%) from one 1999 family lot (total stocked=6,330 fish) was included although they were recaptured only 1 d after stocking (personal communication, Richard Anderson, CDOW, Grand Junction, Colorado).

Of the 84 razorback sucker recaptured 6 months or more following stocking, seven different year classes and 23 different family lots were represented (Appendix; Table E.2.). Eleven of the razorback sucker recaptured originated from one family lot (1992-2A) that were reared at Wahweap SFH. This accounted for 13.1% of the 84 razorback sucker recaptured during this evaluation. Of the 282 fish that were stocked in October 1996 this accounted for a 12.4% recapture rate from this single family lot. A total of 17 fish representing five different lots out of six family lots stocked in October 1996 were recaptured which accounted for 6% of all fish stocked from this family lot. All of these fish had been reared at Wahweap SFH. Ryden (2000) also reported that of 54 known-origin recaptures in the San Juan River, 41 (75.9%) had originated from a single stocking in November 1994. These 41 fish were also from the same family lot as those stocked in the Gunnison River in October 1996 (lot 1992-2A), and also had been reared at Wahweap SFH. The recapture rate from this particular stocking was higher in the San Juan River: 23.2% (41 fish recaptured/177 fish stocked). The mean TL of razorback sucker stocked in the San Juan River was 400 mm (330-446 mm); the mean TL of razorback sucker stocked in the Gunnison River was 343 mm (230-408 mm). This family lot performed well following stocking in the wild which may have been the result of 1) fish averaging over 300 mm at stocking, and 2) genetics (i.e., a good mating combination).

One other family lot, 1998-01, in which 455 razorback sucker were stocked in early-November 1999 in the Gunnison River, displayed a recapture rate of 3.5%. Sixteen of these fish were recaptured 6 months or more following stocking (Appendix; Table E.2.). While the percent recaptured for this family lot is not high, compared to other family lots where considerable numbers of fish were stocked and their respective recapture returns were low, it could be considered meaningful.

Size of Fish Recaptured

Results from razorback sucker recaptured in the Upper Colorado and Gunnison rivers from 1997-2001 following stocking suggest that survival is related to the size of fish stocked. Razorback sucker stocked at sizes greater than 200 mm appear to have better short-term return rates following release in the river than smaller fish stocked (e.g., < 200 mm). Five years of monitoring data for stocked razorback sucker recaptured between 1997 and 2001 were

compiled (Table 2). To date, return rates of razorback sucker stocked at sizes less than 200 mm appear to be very low (0.03%; Table 2). Only four razorback sucker smaller than 200 mm (4.8% of the 84 fish recaptured; Table 2) were recaptured at least 6 months or more following stocking in either the Upper Colorado or Gunnison rivers since stocking commenced in the mid-1990s. The initial assessment that most of the razorback sucker stocked that were less than 200 mm did not survive may be premature. Additional years of monitoring and sampling may reveal that more of these size of fish actually survived. Then, conclusions could be made with a higher degree of certainty as to whether these sizes of stocked fish actually survived or not.

Table 2. Number, percentage, and return rate of stocked razorback sucker (RZ) by size classes (total length, mm) that had been at large for at least 6 months or more following release in the Upper Colorado and Gunnison rivers and were recaptured alive between 1997 and 2001. Note: the 2001 stocking of razorback suckers in the Upper Colorado and Gunnison rivers were not included below.

Size Class Total Length (mm)	Number and Percent of the Total Number of RZ Stocked Apr. 1994–Nov. 2000 ^a That Were Measured	During 1997–2001				Return Rate ^b (%)
		Of 84 RZ Stocked and Later Recaptured				
		(at large for at least 6 months post-stocking)				
		Size at Release		Size at Recapture		
		Number	Percentage	Number	Percentage	
< 100	419 (1.2%)	0	0.0	0	0.0	0.0
100–149	13,776 (38.8%)	1	1.2	1	1.2	0.002
150–199	10,895 (30.7%)	13	15.5	3	3.6	0.03
200–249	7,493 (21.1%)	30	35.7	24	28.6	0.07
250–299	2,186 (6.2%)	6	7.1	12	14.2	0.01
300–349	424 (1.2%)	11	13.1	9	10.7	0.03
350–399	151 (0.4%)	13	15.5	9	10.7	0.03
400–449	85 (0.2%)	6	7.1	13	15.5	0.01
450–499 ^c	38 (0.1%)	3	3.6	11	13.1	0.007
500–549 ^c	19 (0.1%)	1	1.2	2	2.4	0.002
550–599	0 (0.0%)	0	0.0	0	0.0	---
≥ 600	0 (0.0%)	0	0.0	0	0.0	---
Total	35,486 100.0%	84	100.0	84 ^d	100.0	0.2

^a total number of razorback suckers stocked into the Colorado and Gunnison rivers, April 1994 to November 2000: 43,700. Note: 4,189 razorback suckers stocked in 2000 were not individually measured for total length. An additional 4,025 other razorback sucker were not individually measured for total length in years prior to 2000.

^b return rate: calculated as the number of all razorback sucker at the size of release divided by the total number of fish stocked from 1994–2000 (43,700).

^c includes fish collected from Etter Pond in April 1994, implanted with radio transmitters, and stocked into the Upper Colorado and Gunnison rivers.

^d total razorback sucker recaptured by year: 1997=2; 1998=10; 1999=7; 2000=30; 2001=35.

The 200–249 mm class accounted for the highest number of fish recaptured (28.6%), followed by the 400–499 mm group (15.5%), and 250–299 mm group (14.2%) (Table 2). For razorback sucker that had been at large at least 6 months or more following stocking, the 250–499 mm size class accounted for 64.2% of the total number of stocked razorback sucker recaptured from 1997–2001. These size classes comprised only about 8.1% of the total number of razorback sucker stocked (3,549) prior to April 2001 (Table 2). For comparison, similar results have been obtained in the San Juan River where various sizes of razorback sucker have also been stocked. Razorback sucker stocked at ≥ 300 mm TL accounted for 84.3% of all recapture events (i.e., first-, second-, and third-time recaptures) as of 20 September 2001. This is even more significant when only 12.9% of the total number of razorback sucker stocked (6,148) prior to October 2001 were ≥ 300 mm TL (Ryden 2001).

Far less razorback sucker (about one seventh) have been stocked in the San Juan River versus the Upper Colorado and Gunnison rivers. In the San Juan River, 6,147 domestic-reared razorback sucker were stocked between 1994 and 2000 (Ryden 2001) whereas 43,700 hatchery- and pond-reared razorback sucker were stocked in the Upper Colorado and Gunnison rivers during the same period (Table 3). A greater number and percentage of the smaller sizes of

Table 3. Comparison of the number and percentage of razorback sucker stocked by 50-mm size classes between 1994 and 2000 in the San Juan River (Ryden 2001) and the Upper Colorado and Gunnison rivers, and razorback sucker recaptured between 1994 and 2001.

Total Length (mm)	San Juan River			Upper Colorado and Gunnison Rivers		
	Percent of Total Represented by this Size Class	Total Number Stocked	Total Number Recaptured	Percent of Total Represented by this Size Class	Total Number Stocked	Total Number Recaptured
< 51	0.0	0	--	0.0	0	--
51–100	< 0.1	1	0	1.5	531	0
101–150	7.4	455	0	39.4	13,986	1
151–200	46.3	2,848	3	30.7	10,907	3
201–250	30.9	1,905	8	20.6	7,304	24
250–300	2.4	146	3	5.9	2,085	12
301–350	2.9	176	4	1.1	398	9
351–400	6.0	366	26	0.4	150	9
401–450	3.8	233	45	0.2	82	13
451–500	0.2	14	0	0.1	37	11
> 500	< 0.1	3	0	< 0.1	19	2
Totals	100.0	6,147	89	100.0	*35,499	84

* Refers to only fish that were measured. Approximately 8,201 razorback sucker that were stocked were not individually measured for length between 1996 and 2000.

razorback sucker (e.g., 101–200 mm) produced were stocked in the Upper Colorado and Gunnison rivers than those stocked in the San Juan River. For instance, in the Upper Colorado and Gunnison rivers, 70.1% of the fish stocked were between 101 and 200 mm versus 53.7% for fish stocked in the San Juan River. The percentage of stocked razorback sucker between 201 and 250 mm was 20.6% in the Upper Colorado and Gunnison rivers versus 30.9% in the San Juan River. Between 250 and 299 mm, fish stocked in the Upper Colorado and Gunnison rivers comprised 5.9% compared to only 2.9% of those stocked in the San Juan River. In the San Juan River, 792 (12.9% of the total stocked) razorback sucker were stocked ≥ 300 mm TL; 686 (1.9% of the total stocked) razorback sucker were stocked in the Upper Colorado and Gunnison rivers (Table 2). To date, based on post-stocking recaptures of 6 months or more, recapture rates of razorback sucker have been about seven times greater in the San Juan River (89/6,147 or 1.4%) than for stocked fish in the Upper Colorado and Gunnison rivers (84/43,700 or 0.2%; Table 3).

CHAPTER 2: Dispersal of Stocked Fish

Objective 2: determine the dispersal of stocked fish of various sizes following release over time.

One concern when stocking domestic-reared fish in large rivers is the vast downstream dispersal that usually follows release. Often stocked fish travel great distances downstream. While survival can be improved by stocking large fish, managers often have been unable to retain fish in desired locations. The initial downstream movement of stocked fish may be 1) in response to these fish searching for adequate food resources and riverine habitat (personal communication, Edmund Wick, Ft. Collins, Colorado), or 2) fright and behavioral stress related to handling, tagging, stocking, and exposure to a new environment (personal communication, Gordon Mueller, U. S. Geological Survey, Denver, Colorado). Naive domestic-reared fish will undoubtedly find that making the transition from hatchery/pond or raceway conditions to turbid, swift rivers is very stressful. Stocked fish must learn to feed upon natural food sources quickly, learn to identify and escape from predators, and navigate lotic environments. Razorback sucker typically move long distances downstream during the initial period following stocking (Mueller and Marsh 1998; Foster and Mueller 1999). Based on the findings of these researchers with post-stocking movements of razorback sucker in lakes Powell and Mohave and the Lower Green River of Utah, it appears that this transition period is at least 2 weeks long. Studies conducted at San Marcos National Fish Hatchery and Technology Center, Texas, during the 1980s (Carmichael et al. 2001) showed that fish were very susceptible to the considerable stressors associated with poor water

quality and handling associated with harvesting, handling, transporting, and stocking. The physiological stress response is an osmoregulatory dysfunction and the behavioral response is disorientation. These responses can result in aberrant dispersal patterns following stocking.

Based on recapture data, domestic-reared razorback sucker stocked between 1995 and 2001 in the Upper Colorado and Gunnison rivers displayed downstream displacements shortly following stocking. Dispersal following stocking has been predominantly downstream from the release site. Domestic-produced razorback sucker may be extremely susceptible to downstream drift following stocking. The longitudinal distribution, by 10-RM increments, of all razorback sucker recaptured as well as those recaptured 6 months and greater post-stocking in the Gunnison (Figure 4) and Upper Colorado (Figure 5) rivers were graphed. In the Gunnison River where over 18,000 razorback sucker were stocked from 1994–2001, stocked fish were recaptured in all 10-mile segments. Most (25) of these were found in the alluvial reach between Confluence Park boat ramp and Roubideau Creek. Recaptured razorback sucker that had been at large for 6 months or more were found in all of the 10-mile segments except between RM 30 and 39 which is from Bridgeport to approximately Escalante Creek. For razorback sucker that had been at large for 6 months or more, the most fish recaptured (5) were between RM 9–3.9. No stocked razorback sucker were collected between Redlands Dam and the confluence with the Colorado River; however, this 2.3-mile reach of the Lower Gunnison River was sampled only once during 2001. Movement of fish stocked in Colorado waters extended downstream in the Colorado River in Utah. Fourteen razorback sucker stocked in the Upper Colorado and Gunnison rivers in Colorado were later recaptured in either the Colorado (13) or Green (1) rivers of Utah. In the Upper Colorado River approximately 31,500 fish were stocked. All but 20 of these fish were stocked between 1999 and 2001. Recaptured razorback sucker were distributed between RM 179 and RM 20, but were not recaptured in all 10-mile river segments. Most (147) stocked razorback sucker were later recaptured in three, 10-mile river segments (RM 150–179) which include the 15- and 18-mile reaches (RM 185.3–152.7) (Figure 5). This is not surprising since these reaches were sampled more by other researchers conducting concurrent RP studies and evaluations than adjacent up- and downstream reaches. Stocked fish were recaptured as far downstream as Colorado River RM 22.7, 6.5 months after being stocked in the Gunnison River. UDWR biologists recaptured one razorback sucker at RM 124.2 in Westwater Canyon on 24 September 2000. This fish had been at large only 3 d since being stocked earlier in the Gunnison River at RM 57. In this short time, this fish moved downstream almost 104 miles.

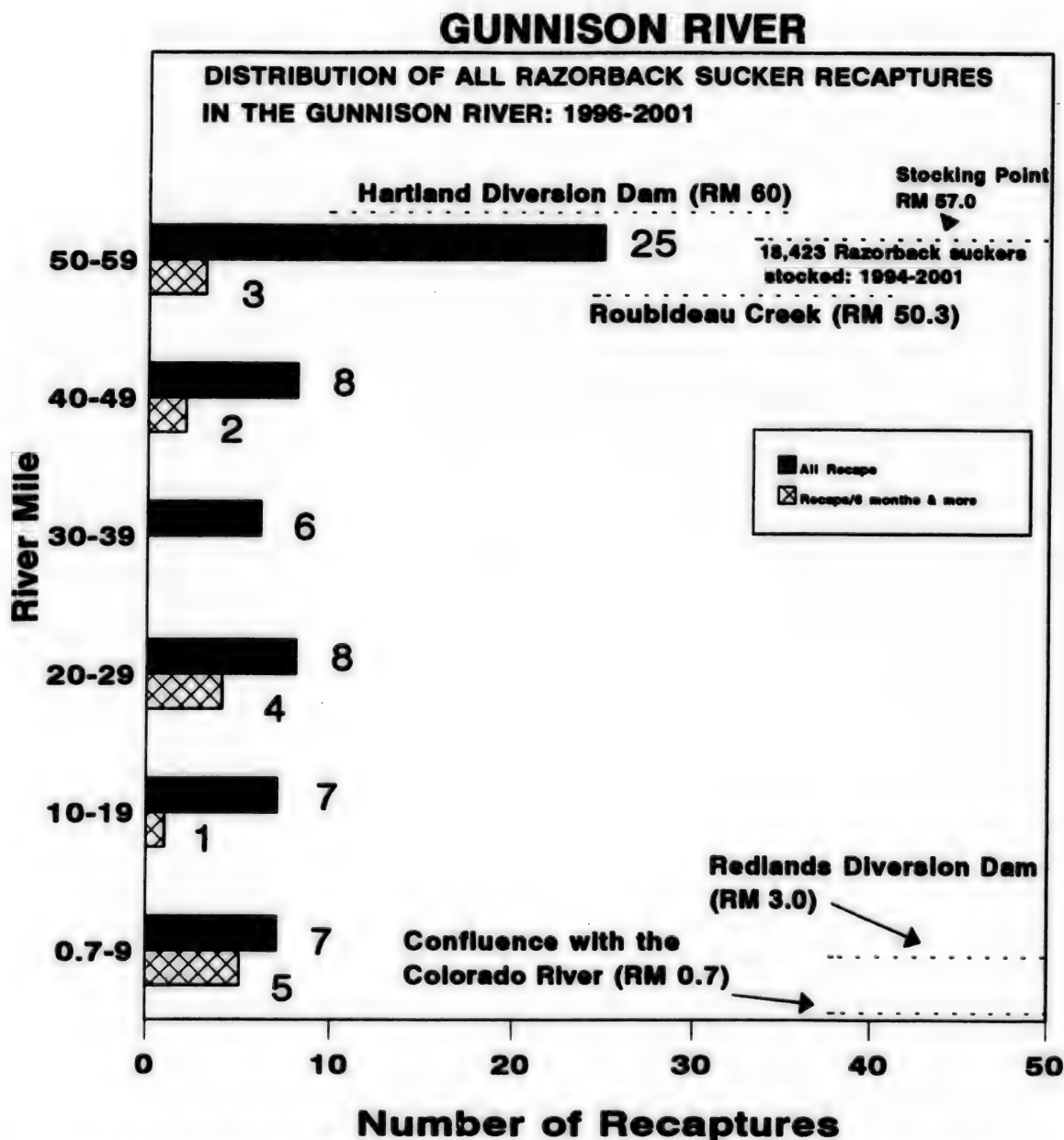


Figure 4. Longitudinal distribution of all razorback sucker recapture events (including second- and third-time recaptures) in the Gunnison River between 1996 and 2001 by 10-mile increments. Numbers to the right of the bars represent the actual number of recapture events. Note: "All Recaps" refers to all razorback sucker recaptured; "Recaps/6 months & more" refers to razorback suckers that had been at large 6 months or more following stocking before being recaptured. The confluence of the Gunnison and Colorado rivers is river mile 0.7. Note: the confluence of the Colorado and Gunnison rivers was re-designated as 0.7 miles upstream from the former confluence (0.0) following the high runoff flows of 1984. The Colorado River created a new channel during the high runoff flows of 1984 which connected the two rivers 0.7 miles upstream from the former confluence.

UPPER COLORADO RIVER

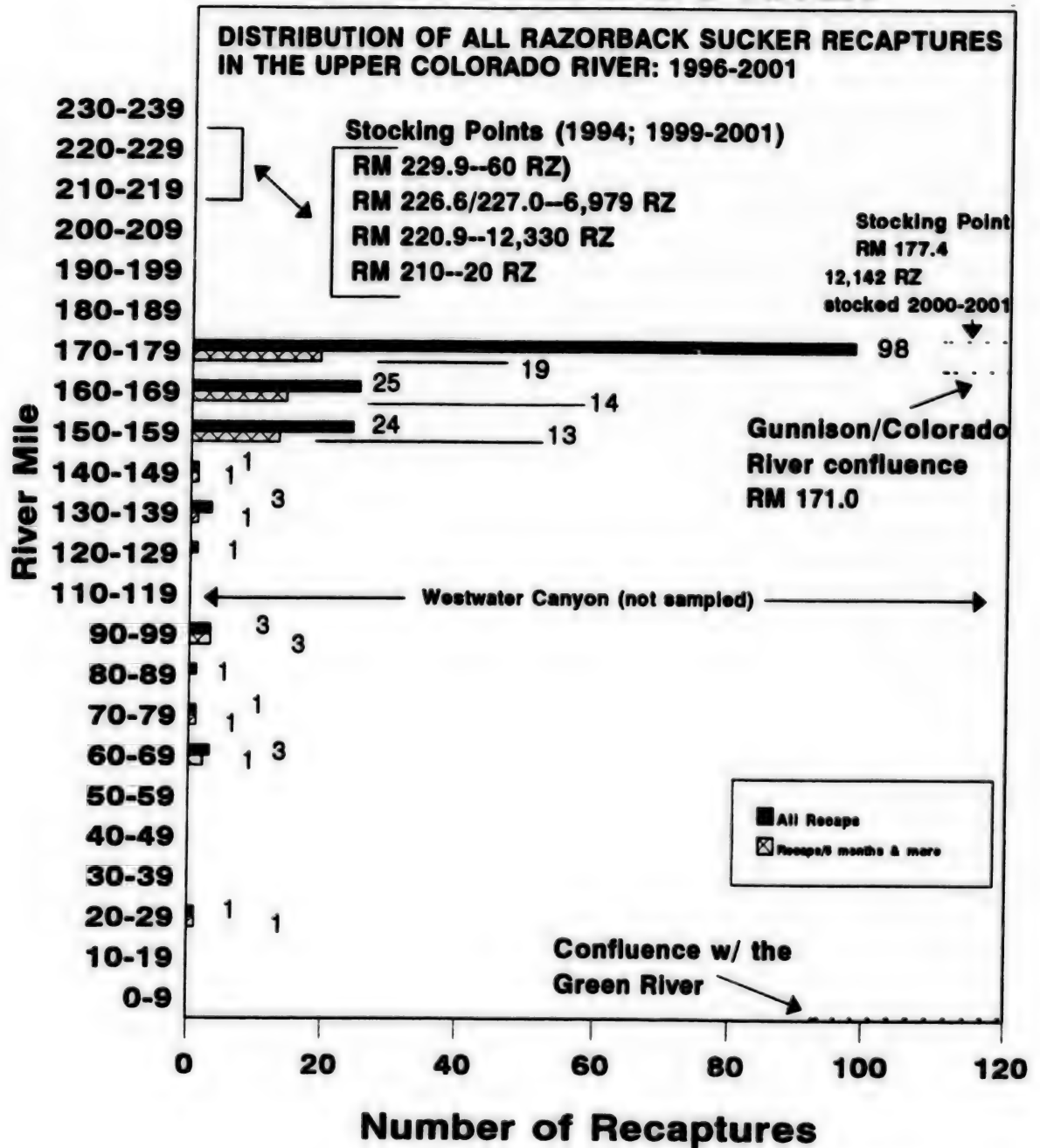


Figure 5. Longitudinal distribution of all razorback sucker recapture events (including second- and third-time recaptures) in the Upper Colorado River between 1996 and 2001 by 10-mile increments. Numbers to the right of the bars represent the actual number of recapture events. Note: "All Recaps" refers to all razorback sucker recaptured; "Recaps/6 months & more" refers to razorback suckers that had been at large 6 months or more following stocking before being recaptured.

Of the 84 recaptured razorback sucker that had been at large for 6 months and more, only four were known to have exhibited upstream movement. Three of the upstream movements were in the Gunnison River and one was in the Green River, Utah. The recapture of a previously stocked razorback sucker by a UDWR biologist was probably the most interesting because it documents another instance of an endangered fish moving between two major hydrologic sub-basins, the Colorado and Green. This razorback sucker was stocked in the Gunnison River at RM 57 on 4 October 1996. The fish's TL and weight at release were 383 mm and 574 g, respectively. This fish was recaptured 3-1/2 years later at the upper most part of Labyrinth Canyon in the Green River (RM 88.9) on 18 May 2000 (TL=474 mm). This fish moved 57 miles downstream in the Gunnison River, 171 miles downstream in the Colorado River to the confluence with the Green River, and then moved about 90 miles upstream in the Green River, a total of about 317 miles. This was the longest movement by any one razorback sucker documented during this study. This fish was progeny of parents that were both from the San Juan River arm of Lake Powell.

Five adult razorback sucker were collected in the fish trap of the Redlands Dam passageway in 2001 between 6 August and 18 September (Burdick 2001). These were the first razorback sucker to ascend the passageway of their own volition and be collected in the fish trap. All five fish had been previously stocked in the Gunnison River. One fish was stocked in October 1996 and had been at large for 1,766 d (4.8 years). The other four razorback sucker all had been stocked in 2001 (three on 3 April and one on 12 June). Two of these fish recaptured in the Redlands passageway fish trap in August 2001 were subsequently recaptured upstream in the Gunnison River later that same year after being released from the fish trap. One of these razorback sucker that was recaptured in the fish trap on 7 August 2001 was recaptured 30 d later 14.9 miles upstream. This fish was stocked 12 June 2001 in the Gunnison River at Delta and had been at large for only 86 d. The second razorback sucker was recaptured in the Redlands passageway fish trap on 28 August 2001 and was recaptured only 8 d later 31.3 miles upstream. The second fish was stocked in the Gunnison River at Delta 3 April 2001 and had been at large for 155 d. The second razorback sucker, then, moved further upstream in a shorter duration than the other razorback sucker after being released from the fish trap.

One adult razorback sucker, previously stocked in the Gunnison River in September 1997 at Delta, was found in the fish trap of the Redlands Dam passageway in mid-July 2002 (Burdick 2002(c)). This fish had been at large about 4.2 years between stocking and recapture.

Two razorback sucker were recaptured in early-June 2000 in Gardner Pond and one in Hotspot Pond (RM 174.4). Gardner Pond is a former gravel-pit that was backfilled, reconfigured

to drain toward the river, and has a man-made connection to the Colorado River. This site was recently evaluated to determine if these type of off-channel habitats can be reconfigured to fill during runoff and benefit endangered fish and drain following runoff to prevent nonnative fish such as centrarchid fishes from proliferating (Burdick 2002(b)). All three fish were hatchery-produced fish that had been stocked into local rivers. One razorback sucker had previously been stocked into the Gunnison River near Delta (RM 57) in early-October 1998. This fish was 411 mm TL at release (431 mm TL at capture) and was from the 1995 year-class. It traveled 57 miles downstream to the Colorado River confluence, moved upstream about 3.4 miles, and negotiated the connection channel to Hotspot Pond before being captured in a trammel net. The second (TL at stocking=130 mm; at recapture=143 mm) and third (TL at stocking=130 mm; at recapture=149 mm) razorback suckers had been stocked in mid-April 2000 near Parachute, Colorado, in the Upper Colorado River (RM 220.9). Before they were each caught in a trap net, they both moved downstream and traversed dams at Government Highline, Price-Stubbs, and Grand Valley Irrigation Diversion. They were also able to locate and negotiate the man-made connection channel into Gardner Pond, a distance of about 47 miles from their stocking location.

Mean down- and upstream displacement (MDD and MUD, respectively) for domestic-reared razorback sucker was computed for fish that had been at large for less than 6 months separately from those that had been at large for 6 months or more between stocking and initial recapture. Initially, MDD from the stocking point for each river was analyzed. Following stocking, razorback sucker moved considerably and significantly further downstream in the Gunnison River than those in the Upper Colorado River. The MDD for razorback sucker in the Gunnison River was 26.3 miles (range=0.1–103.8; n=65) compared to 17.9 miles (range=0.2–88.1; n=72) for fish in the Upper Colorado River that had been at large within 6 months following stocking ($P=0.07$; t-statistic=1.84). This pattern was even more evident for fish that had been at large for 6 months or more as fish stocked in the Gunnison River moved even further downstream. The MDD for fish stocked in the Gunnison River was 3.3 times greater (mean=73.8 miles; range=3.9–228; n=41) compared to an average of 22.1 miles (range=0.0–75.8; n=32) for fish stocked in the Upper Colorado River ($P < 0.0001$; t-statistic=5.55).

Next, displacement analysis was pooled for the Upper Colorado and Gunnison rivers and for razorback sucker recaptured between 1997 and 2001 because of the small sample size of razorback sucker recaptured 6 months or more. For fish at large less than 6 months, the MDD was 21.8 miles (n=124 fish; 0.1–103.8 miles); MUD was < 0.01 miles (n=124 fish; 0.1–0.4 miles). For fish that had been at large for 6 months or more, the MDD was 50.9 miles (n=73 fish; 0.0–228 miles); MUD was 1.3 miles (n=73 fish; 0.1–88.9 miles) (Table 4). Displacement was

Table 4. Displacement (river miles [RM])^a data for domestic-reared razorback sucker between stocking and recapture in the Upper Colorado, Gunnison, and Green rivers, 1996–2001. Up- and downstream movement data for stocked razorback sucker were first partitioned for fish that had been at large for less than 6 months and for fish at large 6 months or more following stocking. Displacement data were further partitioned by 50-mm length groups for fish that moved up- and downstream following stocking for the same two time periods. For razorback sucker that had been at large for less than 6 months, only downstream displacement data by 50-mm length groups were provided because no razorback sucker were recaptured upstream from the stocking site.

	<u>@ Large for < 6 months</u>		<u>@ Large for ≥ 6 months</u>	
	<u>Dnstrm</u>	<u>Upstrm</u>	<u>Dnstrm</u>	<u>Upstrm</u>
No. of razorback suckers recaptured ^b	124	124	73	73
No. of fish that actually exhibited up- or downstream movement between stocking and recapture	124	2	68	4
Mean Displacement (RM)	21.8	< 0.01	50.9	1.3
Range (RM)	0.1–103.8	0.1–0.4	0.0–228.0	0.1–88.9
Std. Dev.	27.1	2.8	49.3	10.4

^a displacement is defined as the maximum distance moved (river miles) by a razorback sucker between the stocking site and recapture location, either upstream or downstream.

^b the number of razorback sucker that potentially moved up- or downstream between stocking and recapture.

<u>@ Large for ≥ 6 months</u>										
Total Length (mm) @ Release	<u>Downstream Displacement</u>					<u>Upstream Displacement</u>				
	No. of Fish	Mean Displmt (RM)	Displmt Min	Displmt Max (RM)	Std. Dev.	No. of Fish	Mean Displmt (RM)	Displmt Min	Displmt Max (RM)	Std. Dev.
50– 99	0	--	--	--	--	0	--	--	--	--
100–149	0	--	--	--	--	0	--	--	--	--
150–199	12	30.1	1.8	73.9	28.8	12	0	--	--	--
200–249	23	37.3	0	205.3	55.7	23	0	--	--	--
250–299	6	76.1	58.7	96.9	11.7	6	0	--	--	--
300–349	10	60.9	1.1	161.6	46.3	10	<0.1	0	0.1	--
350–399 ^a	14	74.6	6.8	228.0	56.6	14	6.4	0.4	88.9	22.9
400–449	6	52.5	29.1	75.3	13.5	6	0.6	0	3.4	1.3
450–499	1	3.9	--	--	--	1	31.3	--	--	--
≥ 500	1	54.0	--	--	--	1	14.9	--	--	--

^a size class includes the razorback sucker captured in the Green River at river mile 88.9.

Table 4 (cont'd).

Total Length (mm) @ Release	@ Large for < 6 months				
	Downstream Displacement				
	No. of Fish	Mean Displmt (RM)	Displmt (RM)		Std. Dev.
			Min	Max	
50- 99	0	--	--	--	--
100-149	56	6.6	0.2	72.7	16.8
150-199	14	50.0	0.1	88.1	23.3
200-249	19	46.6	0.1	103.8	31.2
250-299	6	43.7	0.2	75.8	26.5
300-349	9	17.6	0.7	39.6	14.6
350-399	11	16.5	3.4	39.6	10.7
400-449	3	9.3	2.2	18.9	7.0
450-499	5	14.0	1.5	45.9	16.5
≥ 500	1	54.0	--	--	--

further partitioned by 50-mm length groups for fish that moved up- and downstream following stocking for the same two time periods (Table 4). There were differences between displacement distances displayed for razorback sucker of different size classes (Table 4). However, no clear pattern or relationship emerged regarding an increase or decrease of MDD or MUD displacement versus size of fish stocked. Razorback sucker between 250-299 mm and 350-399 mm displayed the greatest MDD (76.1 and 74.6 miles, respectively). The MDD for the 300-399 mm size group was 60.9 miles and 52.5 miles for the 400-499 mm group. The 150-199 mm size group dispersed an average of 30.1 miles. The MUD varied greatly due to large variability between individual fish and a low sample size for each size class. The MUD ranged from 0.1 mile for 300-349 mm fish to 31.3 miles for one fish in the 450-499 mm size group. For fish that had been at large less than 6 months, the three size groups between 150-299 displayed similar MDD (50.0 versus 46.6 versus 43.7). Razorback sucker that were stocked at larger sizes appeared to move less following stocking than the smaller sizes. The MDD for the four size groups between 300-499 mm gradually decreased (17.6 miles versus 16.5 versus 9.3 versus 14.0). The single fish ≥ 500 mm, however, traveled 54.0 miles downstream.

Displacement data were also partitioned and calculated for each year (Appendix F). For fish that had been at large for 6 months or more following stocking, the MDD was greatest during 1998 (100 miles; n=10 fish), followed by 2000 (75.7 miles; n=30 fish), 1999 (46.4 miles; n=7

fish), 1997 (29.5 miles; n=2 fish), and 2001 (24.8 miles; n=34 fish). The MUD was highest in 2000: 46.2 miles for two fish followed by 2001 where two other fish moved an average of only 1.4 miles upstream. Comparing the two periods between stocking and recapture (i.e., < 6 months versus $\geq$ 6 months), usually the longer the period of time between stocking and the first recapture point, the greater the distance fish were located downstream (Appendix F). Downstream displacement following stocking was anticipated, based on results from domestic-reared fish released in other river systems (Ryden and Pfeifer 1995; 1996; Burdick and Bonar 1997; Ryden 2000; Mueller and Marsh 1998; Foster and Mueller 1999; Mueller and Foster 1999). What was surprising though, and less desired, was the extent of this downstream displacement and apparent low retention of fish within the reach and river where they were released. Fish stocked in the Gunnison River displayed a proclivity to move considerable distances downstream, abandoned the Gunnison River, and eventually moved into the Upper Colorado River. Upstream movements of fish may have gone undetected during this study. Telemetry was not used during this study. Possibly, if some fish had been radio-tagged, more contacts could have been made to detect upstream movements of individual fish versus only the one data point obtained between the point of release and recapture for fish that were only PIT-tagged. The apparent lack of retention of stocked razorback sucker in the Gunnison River may have been exaggerated because more sampling effort was expended in backwaters in the 18-mile reach of the Upper Colorado River by this and other concurrent RP studies than in the Gunnison River. The greater number of razorback sucker recaptured in the Colorado River may, then, have been due to the greater sampling effort in the Upper Colorado River.

The apparent exodus and downstream movement of stocked fish from the Gunnison River to the Upper Colorado River may not pose a problem. With passage now being provided at the Redlands Dam on the Lower Gunnison River, razorback sucker migrating from the Upper Colorado River into the Gunnison River can now move past this 80-year barrier and move further upstream. The collection of six different adult razorback sucker in the fish trap at Redlands in 2001 and 2002 (Burdick 2001; Burdick 2002(c)) is proof that razorback sucker are motivated to actively move upstream and have the ability to use and negotiate a man-made passage structure. The subsequent recapture of two of these fish also demonstrates their motivation to migrate further upstream.

Another important question: will domestic-reared razorback sucker stocked in a river system remain and will they reproduce in the wild? Apparently, they do. Eight razorback sucker larvae were identified from preserved seine and light-trap samples collected in the spring and early-summer of 2002 in the Gunnison River. One larvae was collected in a backwater near the

mouth of Roubideau Creek (RM 50.3), four were collected from zero-velocity habitats at RM 4.8 immediately upstream from the Redlands Diversion Dam, and three were collected downstream from Whitewater between RMs 9.6 and 5.9, also from zero-velocity habitats (personal communication, Dr. Kevin Bestgen, Larval Fish Laboratory, Ft. Collins, Colorado). Since it is believed that wild adult razorback sucker are extirpated in the Gunnison River, razorback sucker previously stocked in this system produced these larval fish. This, then, proves that stocked razorback suckers are spawning in the Gunnison River (personal communication, Doug Osmundson, FWS, Grand Junction, Colorado).

Of 50 razorback sucker released in the Gunnison River at RM 57 and recaptured 6 months or more following release, 31 (62%) were later collected in the Upper Colorado River. Thirty of these fish moved downstream, eventually left the Gunnison River, and entered the Colorado River. Twenty one of these fish were recaptured in the 18-mile reach. One of the 31 fish moved upstream into Gardner Pond. Another razorback sucker traveled downstream to the confluence with the Green River and moved upstream in the Green River. The MDD for these fish was 94.6 miles (57–228 miles). Nineteen of the 50 other razorback sucker stocked in the Gunnison River were recaptured in some part of the Gunnison River between their release point (RM 57) and Redlands Dam 6 months or more following stocking. Their MDD was 33.3 miles (3.9–54.1 miles).

For razorback sucker that were recaptured less than 6 months following stocking, 49 of these fish were collected in the Gunnison River. The MDD from release point to recapture point for these 49 fish was 18.2 miles (0.1–54.0 miles; $n=45$ fish); the MUD was 11.7 miles (0.1–31.3 miles; $n=4$ fish). Two of the fish that moved upstream were fish that had been recaptured in the fish trap of the Redlands Dam passageway in August 2001, but had been at large only for 155 and 86 d.

The downstream dispersal pattern observed for domestic-reared razorback sucker during this 6-year monitoring evaluation was similar to that documented for radiotagged and non-radiotagged (PIT-tagged) fish during former and other ongoing studies in the Upper Colorado, Gunnison, and San Juan rivers. Movement data from pond-reared (Etter Pond) razorback sucker released in the Upper Colorado and Gunnison rivers in 1994 indicated that the majority of downstream displacement occurs within the first few weeks following stocking. The MDD for radiotagged razorback sucker stocked in 1994 in the Upper Colorado and Gunnison rivers that were monitored for 2 years was 19.3 ($n=20$ fish) and 14.3 ($n=21$ fish) miles, respectively. The MUD was much lower for these same fish. The MUD was 4.8 miles for Upper Colorado River fish and only 1.6 miles for the Gunnison River fish (Burdick and Bonar 1997). Radiotagged

razorback sucker exhibited similar movement patterns and behavior following stocking at different sites in the San Juan River (Ryden and Pfeifer 1995; 1996). The MDD for radiotagged razorback sucker in the spring in the San Juan River was 10.5 miles. The MDD for radiotagged razorback sucker stocked during the fall of 1994 (54 miles) and 1995 (58.2 miles) in the San Juan River was greater than those stocked in the spring. During other radiotelemetry studies between 1994 and 1997 for razorback sucker in the San Juan River (Ryden 2000), movement patterns were similar to those of previous studies. Ryden compared movement patterns displayed by razorback sucker implanted with only PIT tags versus those implanted with both radiotags and PIT tags. Recaptured PIT-tagged fish had smaller MDD values (30.4 miles; n=46 fish) than did observed radiotagged fish (35.8 miles; n=38 fish). However, these values were not statistically significant.

Dispersal of domestic-reared razorbacks sucker that had been sonic-tagged and stocked into lakes Powell and Mohave was rapid, widespread (Mueller and Marsh 1998), and similar to earlier studies in Lake Mohave (Mueller et al. 1998). Movement was more pronounced immediately after release and declined with time. Maximum daily distance traveled by individuals released in Lake Powell averaged 1.2 miles/d (0– > 6.4 miles/d). Thirty domestic-reared razorback sucker were equipped with external radio transmitters and released in the Lower Green River at Millard Bottom, Utah. One-half of these fish were released immediately in the river (control group), while the remaining half were held in the canyon's backwater with a block net for 48 hours (experimental group). Fish were tracked for a 60-d period. At day 58, the average dispersal distance for the control group was 50.3 miles whereas the experimental group average dispersal distance was 32.9 miles. All fish in both groups moved downstream. Similar dispersal distances for razorback sucker reared in both the hatchery and grow-out ponds stocked into rivers were observed in the Green River during 1995 (week 1: 24.4 miles downstream; week 3: 54.1 miles downstream (Day and Modde 1999)).

CHAPTER 3: Habitat Use of Stocked Fish

Objective 3: determine habitat use of juvenile (100 mm) or sub-adult (200–300-mm) fish in the riverine environment.

Eighty-four different habitat observations were obtained from stocked razorback sucker, 64 from the Upper Colorado River and 20 from the Gunnison River. These observations were from stocked fish that had been at large 6 months or more following stocking. Observations were from fish recaptured with electrofishing, seines, trammel, and trap nets. Razorback sucker were

collected from eight different habitat types: main channel (4), side channels (1), backwaters (55), shorelines (9), riffles (7), runs (3), eddies/pools (2), and gravel-pits (3) (Table 5). Recaptured fish were more frequently collected from backwater habitats (65%) than any other habitat type. This is probably an important observation because most of the monitoring was with electrofishing that sampled mostly shoreline habitats. Habitat use was further partitioned by 50-mm size classes. Only four, 100–150-mm fish were recaptured. Two of these fish were found in a gravel pit at 29–5/8 Road. Razorback sucker 200–299-mm long were mainly recaptured in backwaters (37 of 43 fish or 86%). Of the 40 fish collected in the Upper Colorado River in this same length group, 93% were found in backwater habitats. Stocked fish 300 mm and larger were also found more in backwater habitats (13 of 31 fish or 42%) than the other habitats reported.

Habitats where these stocked fish were collected did not necessarily indicate habitat preference. More meaningful data would be to determine habitat preferred by razorback sucker that had been at large 6 months or more following stocking. To determine if razorback sucker prefer particular habitat types, usage would have to be compared to habitat availability. However, habitat availability was not determined or calculated in the immediate vicinity when a fish was recaptured.¹ In this study, the priority was to determine 1) size of fish stocked and their subsequent survival, 2) general fish dispersal following stocking, and 3) general habitat of recaptured stocked fish.

CHAPTER 4: Identify Ways to Reduce Mortality of Stocked Fish

Objective 4: identify ways to reduce mortality of stocked fish.

Stock Larger Fish

One strategy that appears to increase post-stocking success of captive-reared razorback sucker is to release them in the riverine environment at sizes large enough to avoid piscivorous predation and at an age when they are not yet domesticated and will likely spawn soon after stocking. Apparently, this strategy has met with success in the San Juan River (Ryden 2000). Ryden recommended stocking razorback sucker at sizes of approximately 400 mm, but not older than 3 years of age because they become domesticated to conditions present at hatcheries and grow-out ponds. The belief is that they are more unlikely to adapt to riverine conditions when held to this age. This may have been the case with adult-size razorback sucker (451–536 mm) captured from Etter Pond, radiotagged, and released in the Upper Colorado and Gunnison rivers

Table 5. Habitats from which stocked razorback sucker were later recaptured from the Upper Colorado and Gunnison rivers between 1996 and 2001.

River: Gunnison

Total Length (mm)	No. of Observations	Habitat Type ^a							
		MC	SC	BA	SH	RI	RU	EP	GP
100-149	1	1	0	0	0	0	0	0	0
150-199	2	0	0	0	2	0	0	0	0
200-249	1	0	0	0	0	0	0	1	0
250-299	2	1	0	0	0	1	0	0	0
300-349	1	0	0	0	1	0	0	0	0
350-399	3	0	0	2	0	1	0	0	0
400-449	3	0	0	0	0	3	0	0	0
450-499	6	1	0	0	3	2	0	0	0
≥ 500	<u>1</u>	0	0	0	1	0	0	0	0
Totals	20								

River: Upper Colorado

Total Length (mm)	No. of Observations	Habitat Type ^a							
		MC	SC	BA	SH	RI	RU	EP	GP
100-149	3	0	0	1	0	0	0	0	2
150-199	5	0	1	4	0	0	0	0	0
200-249	27	0	0	27	0	0	0	0	0
250-299	13	1	0	10	0	0	2	0	0
300-349	5	0	0	5	0	0	0	0	0
350-399	2	0	0	2	0	0	0	0	0
400-449	5	0	0	1	1	0	1	1	1
450-499	5	0	0	3	1	0	0	0	0
≥ 500	<u>0</u>	0	0	0	0	0	0	0	0
Totals	64								

^a Habitat Type: MC=main channel; SC=side channel; BA=backwater; SH=shoreline; RI=riffle; RU=run; EP=eddy/pool; GP=gravel pit.

in 1994 (Burdick and Bonar 1997). These fish demonstrated poor post-stocking survival over a period of 3–6 months. Mortality was delayed and occurred over several months following stocking. Mortality rates were 85% for Upper Colorado River fish and 88% for Gunnison River fish. At the time of radio-tag implantation, their body cavities had vast amounts of fat, indicating that they were in good condition in the spring prior to being released in the river. These researchers speculated that the reasons for poor survival of these adult razorback sucker may have been due to their inability to cope with the new riverine conditions (i.e., currents, turbidity, and fluctuating flows), or being unable to learn to use natural food items, thus leading to eventual starvation. These older fish (possibly as old as 11 to 12 years of age at the time of stocking) may simply have been too domesticated to their artificial pond environment to be able to survive in riverine conditions, a situation known as domestication selection (Burdick 1992; Ryden and Pfeifer 1994; see Williamson 2001).

Site Acclimation

Other researchers have suggested that, in addition to stocking larger fish, behavioral acclimation could influence short-term dispersal rates of stocked razorback sucker (Mueller and Marsh 1998). If initial stocking behavior can be influenced, it might enhance the probability of stocked fish remaining in the target reach, and improve survival by reducing post-stocking behavioral stress and predation exposure. Mueller and Marsh (1998) suggested holding fish on site for 3 d may influence dispersal rate. Allowing stocked razorback sucker to slowly acclimate in a backwater before migrating to other riverine habitats might reduce physiological and behavioral stress (Burdick and Bonar 1997). A 3-d, pre-stocking acclimation period significantly altered the dispersal rates of domestic-reared fish stocked in the Lower Green River (Mueller and Marsh 1998). However, they and other researchers (Pottinger and Pickering 1992) recommended that a longer acclimation period (i.e., 2–4 weeks) was still needed for razorback sucker to remain near the release site. One of the current practices include stocking razorback sucker as far upstream as possible in suitable warmwater habitat (Burdick and Bonar 1997; Ryden and Pfeifer 1996). This technique requires that a great many fish be stocked at a far distant location due to the low probability that a particular fish will survive, move downstream a set distance, and become a resident in a targeted river reach. Foster and Mueller (1999) suggested that razorback sucker should be site-acclimated which could ameliorate the extensive downstream drift following stocking. The extension of this recommendation is that if fish are allowed to acclimate, post-stocking stress and trauma may be reduced thus increasing survival.

Floodplain Stocking

Other researchers (Modde et al. 2001) have promoted a different approach. They contend that razorback sucker should be stocked in floodplain wetland environments that remain inundated year-round and that seasonally connect to the river. These researchers believe that this will provide more effective stocking results (i.e., higher return rates and therefore greater post-stocking survival). Fish should be allowed to remain in such habitats to grow for at least 1 year. They then could voluntarily infiltrate to the river, most likely during spring runoff when the floodplain/wetland connects with the river. Apparently, this strategy has met with some success. Riverine recapture rates of fingerling razorback sucker reared for one growing season in off-channel wetlands that accessed the river voluntarily as sub-adults ($n=1,100$) were compared with sub-adult razorback sucker (> 250 mm) that were stocked directly into the Green River from the hatchery ($n=2,000$). Nearly three times (74) as many acclimated fish (i.e., floodplain-reared fish) were recaptured than those stocked into the river directly from the hatchery (29). The distribution of razorback sucker downstream from the stocking area was approximately equal between the two groups.

Razorback sucker stocked into floodplain wetlands in the middle Green River, Utah, and overwintered in these habitats later moved into the river after 12 months (at Age-1 [~ 100 mm]). Some of these fish have been subsequently found at three different gravel bars during the spawning season (personal communication, Tim Modde, FWS, Vernal, Utah). These three locations are the Escalante site in the middle Green River, a site downstream from the Price River in the lower Green River, and most recently, in the White River, Utah.

Flow Conditioning

Determining if conditioning captive-reared razorback sucker to flow and current prior to being stocked into the riverine environment has also been discussed as a means to reduce the distance stocked fish are displaced downstream immediately following stocking, and if this improves long-term survival (Wydoski 1994; Burdick and Bonar 1997). Some researchers speculated that fish reared in hatcheries or rearing ponds might not have developed adequate muscle tone to cope with flowing habitats (Crowl et al. 2000). Laboratory investigations that were conducted proved inconclusive. However, stocking razorback sucker reared in a hatchery or grow-out pond into riverine habitats without any prior conditioning does not guarantee failure. Razorback sucker stocked into the San Juan River survived for almost three years and appeared in

good condition when recaptured (Ryden and Pfeifer 1996). Recapture rates for larger stocked razorback sucker (mean and range [TL]: 364; 204–482) were greater than smaller sizes stocked (mean and range [TL]: 190; 100–374). During monitoring of the San Juan River over a period of 31 months following stocking, only three of the 478 (0.6%) smaller-sized razorback sucker were recaptured whereas 46 of the 461 (10%) larger-sized razorback sucker were recaptured (personal communication, Dale Ryden, FWS, Grand Junction, Colorado). Neither of these two groups of razorback sucker had been conditioned prior to release. For razorback sucker recaptured from Etter Pond in 1994 and later stocked in the Upper Colorado and Gunnison rivers, some of the mortality might have been attributed to lack of conditioning, but many other factors, which were previously discussed, could have been involved.

Spring vs. Fall Stocking

The number of razorback sucker stocked in the spring prior to runoff (5,060 fish) was nearly one-ninth those stocked between August and November (44,347 fish) in the Upper Colorado and Gunnison rivers from 1995 to 2001. Ten of the razorback sucker stocked in the spring were later recaptured which is about a 0.2% return rate. Only two fish stocked in the spring of the year were later recaptured at least 6 months following stocking. Eight other razorback sucker stocked in the spring of the year were later recaptured but had been at large for less than 6 months following stocking. Two hundred sixteen razorback sucker stocked between August and November were later recaptured which is about a 0.5% return rate. Eighty two of these razorback sucker were recaptured 6 months or greater following stocking; 134 were recaptured but had been at large for less than 6 months following stocking. Therefore, the return rate for fish stocked in the spring prior to runoff in the Upper Colorado and Gunnison rivers was about one half of those fish stocked following runoff. For razorback sucker stocked in the spring and fall in the Upper Colorado and Gunnison rivers, displacement for recaptured razorback sucker was predominantly downstream. Comparing spring versus fall released fish, the distance was nearly identical (average displacement for spring: 49.1 miles downstream; fall: 52.0 miles downstream). This comparison may not be exactly representative because the sample size for razorback sucker released in the spring prior to runoff was small ($n=2$) compared to the fall ($n=82$). This was because the analyses included only razorback sucker that had been at large for 6 months or more.

Considerable discussion has taken place on the issue of spring versus fall stocking. Sufficient data is still unavailable to determine what time of the year is best to stock captive-

reared razorback sucker and provides the best return rate. However, data from the post-stocking movements of radio-tagged and subsequent recapture data from non-radiotagged, PIT-tagged, domestic-reared razorback sucker have provided some insight as to when is the best time of year to stock. The merits of spring versus fall stocking were discussed by Ryden (2000) for razorback sucker stocked in the San Juan River, and by Burdick and Bonar (1997) for razorback sucker stocked in the Upper Colorado and Gunnison rivers. Based on post-stocking displacement data alone, Ryden believed that the best time to stock domestic-reared razorback sucker was in the spring (i.e., late-March or early-April). Radio-tagged razorback sucker stocked in the spring of 1994 had smaller downstream displacements than did fish stocked in the fall of 1994, 1995, or 1996. Once initial downstream displacements associated with stocking occurred, these fish demonstrated the ability to maintain their relative position in the river during high-water periods, even in the lower canyon-bound reaches of the San Juan River. He also believed that stocking in the spring allowed fish to adapt to their new riverine conditions before their first winter season and freed up hatchery facilities and grow-out ponds for use in raising new lots of young razorback sucker to be stocked.

Burdick and Bonar (1997) recommended stocking captive-reared razorback sucker in the spring prior to runoff, if the target fish had attained the desired size for stocking. However, Colorado's stocking plan (Nesler 2001) calls for stocking razorback sucker in the fall. No reason was given for fall stocking, but it can be speculated that the size of fish recommended to be stocked (≥ 300) represents the estimated size of razorback sucker that could be produced after the third growing season (e.g., about 2-1/2 years). Razorback sucker would not attain an average size of 300 mm until the fall of the third year.

The disadvantage of stocking fish in the spring is that razorback sucker have less time to grow before being stocked, i.e., if they have not attained the desired size for stocking prior to spring runoff. Based on recapture percentages, razorback sucker stocked in the San Juan River survive better when stocked at larger sizes (i.e., > 350 mm TL; Ryden 2000). Providing enough facilities and grow-out ponds to produce enough razorback sucker of this size can be a dilemma because the number of fish that can be held and reared at any facility is limited. This number becomes even more reduced as fish in those facilities grow to larger sizes. Therefore, if fish are held until fall and reared to larger sizes, there is less space at hatchery facilities for new year-classes of fish to be held and reared. Moving fish from hatchery facilities to grow-out ponds can alleviate this problem and free up space for new year-classes of razorback sucker. In reality and practicality, the decision to stock fish in the spring or fall appears now to be based on the availability of hatchery facilities, the number and acreage of grow-out ponds, the number of

razorback sucker currently being reared and held in these facilities, and the number and size of razorback sucker needed to accommodate recommended stocking goals.

CHAPTER 5: Evaluate Different Gear Types for Sampling Stocked Fish

Objective 5: evaluate different gear for sampling juvenile and sub-adult razorback sucker that will be needed to develop a monitoring program for this species.

Only two active gear types were used to monitor and collect stocked razorback sucker during this evaluation in riverine and bottomland habitats: seines and boom electrofishing from aluminum jon boats and rubber rafts. Electrofishing was by far used more than any other gear type during the monitoring of stocked razorback sucker in the Upper Colorado and Gunnison rivers, mostly, because many habitats within long river reaches could be sampled over a shorter-period of time than with other gear types. In the Upper Colorado and Gunnison rivers, 69.8 and 317.7 h, respectively, of actual electrofishing were conducted from 1996–2001 (Appendix B). Therefore, it was understandable that most of the razorback sucker collected during this 6-year monitoring frame were with electrofishing (174). No razorback sucker were collected with seines (effort=8,584 m²) during the fall of 1995. Only three razorback sucker were collected with seines in riverine habitats (Trammel et al. 2002). Two other stocked razorback sucker were collected with a seine in a pool of the Grand Valley Water User's Canal near 31 Road after the canal had been drained in the fall (Martinez 2001; 2002). One fish was collected in October 2000 and another during October 2001. One juvenile razorback sucker stocked in the Upper Colorado River at RM 220.9 near Parachute in mid-August 2000 was collected in the Grand Valley Irrigation Company (GVIC) Canal near Palisade with electrofishing in mid-November 2002. This fish (TL=283 mm) was captured about 1.5 miles from the point where the canal diverts water from the Colorado River near Palisade. This razorback sucker along with several thousand (3,181 fish) other native flannelmouth sucker, bluehead sucker, and roundtail chub were stranded in the canal after water from the Colorado River had been turned off following cessation of the irrigation season. Collection of native fish in the GVIC canal during mid-November 2002 was a cooperative effort among the GVIC, CDOW, and FWS to determine the number and extent of fish stranded in this canal following water being turned off to irrigation users. All native fish collected in the canal were returned to the Colorado River in the 15-mile reach (unpublished FWS data, Grand Junction, Colorado).

Some razorback sucker were caught passively with trammel (41) and trap nets (3) at site-specific locations in the Upper Colorado River and other razorback sucker were collected passively in the fish trap at the Redlands Diversion Dam (6). For the most part, while different gear types were used to accomplish different objectives among various RP studies, they were not evaluated during this study to determine which was more effective for collecting stocked razorback sucker. One reason for this was the disproportional use of electrofishing compared to the other gears. In the San Juan River, Ryden (2000) concluded that electrofishing appeared to be the most efficient method for monitoring experimentally-stocked razorback sucker, although electrofishing has been and continues to be used almost exclusively in that river system, too.

A valid concern is the reliance on one sampling gear (i.e., boat electrofishing) and the potential biases associated with size-selectivity and the inability to effectively sample in all habitat types. This is potentially important because of the affinity of stocked razorback sucker for low-velocity habitats such as backwaters, which may not be accessible by boat under all conditions. If water depth limits the use of electrofishing craft in backwaters, trap nets might be more practical to use. Sampling gear and technique must suit the life history stage and habitat constraints to be most effective. For example, if only larger fish are stocked and electrofishing is most effective for that size of fish where it is typically found, sampling effort will be reduced for other life stages where they are most likely found. A certain proportion of effort should be dedicated for looking for evidence of natural reproduction and recruitment — even if smaller fish are no longer stocked.

CONCLUSIONS

1. The number of razorback sucker recaptured that were stocked at lengths less than 200 mm was low, and therefore, post-stocking survival may be related to the size of razorback sucker stocked. Larger size-classes (> 200 mm) had a higher recapture rate than did razorback sucker stocked at smaller sizes. This was substantiated by a single family lot (1992-2A) that had the highest return of any other family lot stocked; the average length at stocking was 343 mm TL. Stocking razorback sucker smaller than 200 mm may be futile because it is assumed that their post-stocking performance (i.e., survival) in the wild was poor. Greater returns and thus higher survival may be obtained if larger (> 200 mm), but fewer, razorback sucker are stocked into riverine environments.
2. Dispersal was predominantly downstream from the release site following stocking.

3. Recaptured razorback sucker were more frequently collected from backwater habitats (65%) than any other habitat type.
4. Electrofishing appears to be a practical method for monitoring stocked razorback sucker because many habitats within extensive river reaches can be sampled over a shorter-period of time than with other gear types. However, it remains uncertain whether electrofishing is the most efficient method because it is size-selective (i.e., selects for larger fish). Moreover, trap nets may be more practical to use where electrofishing craft cannot negotiate shallow backwater habitats. For the most part, while different gear types were used to sample and monitor stocked razorback sucker, they were not evaluated to determine which was more effective in collecting stocked razorback sucker.

RECOMMENDATIONS

The following recommendations are made:

1. a) Continue stocking domestic-raised razorback sucker in the Upper Colorado and Gunnison rivers that fulfills present stocking plans and that is consistent with recovery goals identified for the species.
b) Stock razorback sucker greater than 200 mm. This recommendation fulfills objective numbers 1 and 6 of this study: *to determine the relationship between the size of razorback sucker stocked at 100 mm, 200 mm, and 300 mm TL and their subsequent survival in the wild, and to provide recommendations for the optimum size(s) for stocking razorback sucker into Upper Colorado River Basin rivers.*

This recommendation varies from the State of Colorado's stocking plan for razorback sucker (Nesler 2001) which called for producing a 300-mm, domestic-reared razorback by the age of 2 + before stocking into the mainstem Upper Colorado and Gunnison rivers in Colorado. The expectation is that long-term survival will be greater if larger, but fewer, razorback sucker that are less than 4 to 5 years of age are stocked rather than stocking large numbers of smaller fish. A newly formulated stocking plan that integrates former stocking plans by the states of Colorado and Utah and the San Juan River prescribes stocking 9,930, 300 mm razorback sucker, if available, starting in the fall of 2003. The number of razorback sucker stocked annually are to be split equally (3,310 fish) among three river reaches in Colorado. In the Upper Colorado River, the two reaches are from 1) Rifle to Debeque Canyon and 2) Palisade to Stateline, and the third, in the Gunnison

River from Hartland Dam to Redlands Dam. All of these reaches are within critical habitat for the razorback sucker. The stocking of 9,930 razorback sucker per year is now recommended to continue for 6 years to meet the objective of establishing a multi-age group adult population at the designated population abundance level and estimated survivorship (see Ryden 2001) as defined in the recovery goals (FWS 2002) for this species. The objective is to achieve a minimum viable population of 5,800 adult fish from ages five to seven distributed over 150 river miles among the three river reaches in Colorado.

By comparison, for the San Juan River, Ryden (2000) recommended stocking razorback sucker at sizes of approximately 400 mm, but not older than 3 years of age. Ryden also believed that stocking this size of razorback sucker essentially placed them past the predation threshold, and they would likely spawn soon after stocking. Mueller and Marsh (1998) concurred with Ryden's recommendation for augmenting San Juan River stocks with 400-mm size fish. They further suggested that stocking be delayed until winter when predators were dormant (Marsh and Brooks 1989). Day and Modde (1999) also recommended stocking larger razorback sucker (i.e., 300 mm and no less than 250 mm TL).

2. Monitor stocked razorback sucker following release, and at a frequency necessary to determine a) survival, b) dispersement, c) river-reach retention, d) distribution, and e) abundance. (see Nesler 2001).
 - a) Validation of post-stocking survival in the wild is critical and one of the cornerstones for determining whether demographic recovery targets of fish abundance are being achieved. Determining post-stocking survival rates of domestic-reared razorback sucker in the wild is important because this will provide managers the projected time line to achieve recovery. The rate at which populations become established will depend on the post-stocking survival of domestic-reared razorback sucker in the wild, integration of stocked fish with wild stocks, reproductive success, and recruitment in the wild.
 - b/c/
 - d/e) Based on initial and long-term maximum and average downstream dispersement distances following stocking from this and other studies, monitoring should be conducted at least 60 miles downstream from the release point. Other ongoing sampling programs should be notified and encouraged to report pertinent data (locations and date) and PIT tag IDs for recaptured razorback sucker to the

Interagency Standardized Monitoring Program data base manager in Grand Junction. A rigorous, basin-wide monitoring program should be established to estimate the abundance of adult fish and track the long-term status of razorback sucker populations. Sampling should include existing RP field studies to facilitate multiple use of the data. Long-term monitoring will also determine if the objectives identified in the recovery goals are being met which are to establish minimum viable populations at the designated abundance levels in the three identified river reaches in the Upper Colorado and Gunnison rivers.

Backwater habitats should be sampled more regularly in a monitoring program since 65% of stocked razorback sucker were subsequently recaptured in this habitat.

3. Continue marking razorback sucker stocked in the wild with PIT tags (see Nesler 2001).
4. Continue to measure individual marked (PIT tagged) razorback sucker to be stocked. This will allow determination of possible size-dependent effects on survival that could further refine future fish culture and stocking practices (see Bestgen et al. 2002).
5. Monitor the subsequent reproductive contribution to the adult razorback sucker population. Sampling with 0.5-mm bar mesh nets and light traps in quiescent habitats is an effective means to detect reproduction by even a relatively small population of razorback suckers. Sampling with these two gears types in the Gunnison River to collect larval fish during and immediately after the suspected spawning season and determining if larval razorback sucker are present among the samples commenced in the spring of 2002 (RP Project Number 121). Apparently, razorback sucker previously stocked in the Gunnison River are spawning there. Eight razorback sucker larvae that were collected from the Gunnison River between Delta and Redlands Diversion Dam during the spring and early-summer of 2002 were identified from preserved samples by the Larval Fish Laboratory, Ft. Collins, Colorado (personal communication, Dr. Kevin Bestgen). This sampling will continue again in 2003 and 2004 in the Gunnison River to determine if domestic-reared razorback sucker stocked in the Gunnison River are successfully spawning. This sampling should be expanded to reaches of the Upper Colorado River.
6. Identify spawning areas. Spawning areas of razorback sucker in the Upper Colorado and Gunnison rivers should be identified so that these sites can be further protected. Identifying spawning areas could be accomplished by implanting adult razorback sucker with radio transmitters to determine if they can lead researchers to spawning sites in these river systems. Adult razorback sucker being produced and stocked to meet the annual stocking quota recommended in the stocking plan for the State of Colorado and

broodstock that are in excess of those needed for production of progeny and designated as suitable for stocking in the Upper Colorado and Gunnison rivers could be used.

7. Conduct genetic monitoring. Determine if genetic diversity is being maintained in offspring similar to that of wild stock. Collect the appropriate genetic material or sacrifice offspring from various representative family lots produced from mating crosses to determine if the appropriate genetic variability and integrity of progeny are being maintained in accordance with the RP genetics management plan using the current breeding strategies.
8. Temper transport water and add salt. This fulfills objective number 4: *identify ways to reduce mortality of stocked fish.*

If the receiving water temperature is greater than 5° C warmer than the transport water, one-half of the transport water should be exchanged with the receiving water. Ideally, the period of time for water exchange is about 1 hour for every 1° C over the 5° C limit. More practically when time is not available, others have suggested that the transport water temperature should be tempered slowly to meet the receiving water temperature. However, other factors may be involved (e.g., water chemistry), and may be more important than water temperature (Piper et al. 1982). Osmotic shock can be very serious and transported fish may be subjected to carbon dioxide and oxygen tension that are not present in the receiving water. Following handling and marking, fish destined for stocking should be transported in water with 0.5% salt. Research has been conducted that identifies several actions during the harvesting, handling, and transporting that can stress and kill fish (Carmichael et al. 2001). From this research, some general guidelines and techniques have been developed that allow for safer handling and transport of fish. Handling and transport protocols have been developed that can 1) reduce the severity of stressors, 2) minimize the duration of stressors, 3) reduce the number of stressors, 4) minimize plasma ion disturbances, and 5) minimize increases in metabolic rate. Specific handling and transporting procedures and protocols that have been extensively discussed and established (see Carmichael et al. 2001) for warmwater endangered fishes should be followed as initial guidelines, given that on certain situations some novel improvisations may be needed. These specific procedures will not be discussed or reiterated here. All of these measures are intended to provide the best conditions during harvesting, handling, and transporting domestic-reared razorback sucker and to enhance the likelihood for stocked fish to survive following stocking.

9. Test the utility of site-acclimating stocked razorback sucker. This fulfills objective number 4: *identify ways to reduce mortality of stocked fish.*

a) Riverine Backwaters. Domestic-reared razorback sucker may have to be held for some period of time in backwater habitats before they are allowed to migrate voluntarily to the river. Holding stocked fish for at least 2–3 d in riverine surroundings for low densities of razorback sucker has significantly altered and reduced average dispersal rates and ranges of razorback sucker (Mueller and Foster 1999). However, a longer period of acclimation may be needed for razorback sucker to remain near the release site, possibly up to 1 week. Stocked razorback sucker could be released in backwaters blocked off with netting to prevent them from escaping into the river. This could allow fish to acclimate to riverine conditions, reduce initial trauma and stress due to handling and transport, and ultimately decrease downstream dispersement. A sub-sample of these stocked razorback sucker could be implanted with radio transmitters and their subsequent movements monitored. Unfortunately, when large numbers of razorback sucker are to be stocked day after day during the fall, when fish are being harvested, marked, and released, it may be difficult locating an adequate number of backwater habitats to hold all of these stocked fish.

b) Floodplain Sites. Future stocking efforts should include the testing, and eventual habitat acclimation, including both site acclimation (short-term) and rearing acclimation (long-term) (Day and Modde 1999), that utilizes floodplain depressions. Along the Upper Colorado River in the Grand Valley near Grand Junction, current sites being remediated for selenium could provide opportunities for site-acclimating domestic-reared razorback sucker. These sites should be absent of or contain low densities of nonnative piscivorous fishes (e.g., sunfishes and ictalurids) if razorback sucker < 250 mm are stocked. Larger, domestic-reared razorback sucker (e.g., > 250 mm) could be stocked into sites where high densities of nonnative fish occur because they would be large enough to avoid predation. These sites would serve as intermediate habitat between the hatchery or grow-out pond. Domestic-reared razorback sucker stocked into these sites could then be allowed to leave of their own volition and move to the river.

UNCERTAINTIES

1. Was the low return rate reported during this study representative of the low survival in the wild following stocking for razorback sucker stocked at < 200 mm? Or, was the survival of these razorback sucker between 1995 and 2001 greater in the wild than that observed during this evaluation?
2. What are the actual survival rates of domestic-reared razorback sucker that are stocked in the wild?
3. What time of the year, spring or fall, should domestic-reared razorback sucker be stocked that would yield the best survival?
4. Will stocked fish remain in reaches where suitable habitat for spawning may be available, or do stocked fish have the ability to migrate to these habitats?
5. Will suitable mainstem and/or floodplain habitat for razorback sucker reproduction and rearing be available if appropriate flows are delivered to the three reaches identified for re-introduction?
6. More importantly, now that stocked fish have reproduced in the wild (Gunnison River in 2002), will their progeny recruit into the adult population?
7. Can one minimum viable population in the Gunnison River or two in the Upper Colorado River be established under the aforementioned habitat conditions, and when?
8. What gear type(s) or combination of gears, methods, and strategies will provide the most effective means of monitoring and determining population abundance and densities of adult razorback sucker?

LITERATURE CITED

- Bestgen, K. R. 1990. Status review of the razorback sucker, *Xyrauchen texanus*. Contribution 44, Colorado State University Larval Fish Laboratory. Ft. Collins.
- Bestgen, K. R., G. B. Haines, R. Brunson, T. Chart, M. Trammell, R. T. Muth, G. Burchell, K. Christopherson, and J. M. Bundy. 2002. Status of wild razorback sucker in the Green River Basin, Utah and Colorado, determined from basinwide monitoring and other sampling programs. Final Report prepared for the Upper Colorado River Endangered Fish Recovery Program. Recovery Program Project Number 22D. Contribution 126, Colorado State University Larval Fish Laboratory. Ft. Collins.

- Burdick, B. D. 1992. A plan to evaluate stocking to augment or restore razorback sucker in the Upper Colorado River. Final report. U. S. Fish and Wildlife Service, Colorado River Fishery Project, Grand Junction, Colorado. 56 pp.
- Burdick, B. D. 1995. Ichthyofaunal studies of the Gunnison River, Colorado, 1992-1994. Final Report prepared for the Recovery Implementation Program for Endangered Fishes in the Upper Colorado River Basin. Recovery Program Project Number 42. U. S. Fish and Wildlife Service, Colorado River Fishery Project, Grand Junction, Colorado. 60 pp + appendices.
- Burdick, B. D. 2001. Evaluation of the effectiveness of the fish passage structure at the Redlands Dam. Annual report prepared for the Recovery Implementation Program for the Endangered Fishes of the Upper Colorado River Basin. Recovery Program Project Number C-4b. U. S. Fish and Wildlife Service, Colorado River Fishery Project, Grand Junction, Colorado.
- Burdick, B. D. 2002(a). Evaluation of stocking sub-adult Colorado pikeminnow via translocation in the Upper Colorado River between Palisade and Rifle. Draft Final report prepared for the Recovery Implementation Program for the Endangered Fishes of the Upper Colorado River Basin. Recovery Program Project Number 105. U. S. Fish and Wildlife Service, Colorado River Fishery Project, Grand Junction, Colorado.
- Burdick, B. D. 2002(b). Evaluating the use of sloped gravel-pit ponds by listed and non-listed native fishes and removal of nonnative fishes from sloped gravel-pit ponds in the Upper Colorado River near Grand Junction, Colorado. Final Report prepared for the Recovery Implementation Program for the Endangered Fishes of the Upper Colorado River Basin. Recovery Program Project Number C-6-GP. U. S. Fish and Wildlife Service, Colorado River Fishery Project, Grand Junction, Colorado. 50 pp + appendices.
- Burdick, B. D. 2002(c). Evaluation of the effectiveness of the fish passage structure at the Redlands Dam. Annual report prepared for the Recovery Implementation Program for the Endangered Fishes of the Upper Colorado River Basin. Recovery Program Project Number C-4b. U. S. Fish and Wildlife Service, Colorado River Fishery Project, Grand Junction, Colorado.
- Burdick, B. D., R. S. Wydoski, and C. W. McAda. 1995. Stocking plan for razorback sucker in the Upper Colorado and Gunnison rivers. Final report prepared for the Recovery Implementation Program for the Endangered Fishes of the Upper Colorado River Basin, U. S. Fish and Wildlife Service, Grand Junction, Colorado. 13 pp.
- Burdick, B. D., and R. B. Bonar. 1997. Experimental stocking of adult razorback sucker in the Upper Colorado and Gunnison rivers. Final report prepared for the Recovery Implementation Program for the Endangered Fishes of the Upper Colorado River Basin. Recovery Program Project Number 50. U. S. Fish and Wildlife Service, Colorado River Fishery Project, Grand Junction, Colorado. 28 pp + appendices.

- Carmichael, G. J., J. R. Tomasso, Jr., and T. E. Schwedler. 2001. Fish transportation. Pages 641–660 in G. A. Wedemeyer, editor. Fish hatchery management, second edition. American Fisheries Society, Bethesda, Maryland.
- Crowl, T. A., G. Bissonette, G. Thiede, L. Alder, and S. Rivera. 2000. Bonytail Chub. Prepared for the Utah Division of Wildlife Resources, 1998 Annual Report, Utah State University, Ecology Center, Logan, Utah. 73 pp.
- Czapla, T. E. 1999. Genetics management plan (revised). Recovery Implementation Program for the Endangered Fishes of the Upper Colorado River Basin, U. S. Fish and Wildlife Service. Denver, Colorado. 48 pp.
- Czapla, T. E. 2002. Facilities plan for the production of endangered fishes to meet state stocking plans as part of the Upper Colorado River Endangered Fish Recovery Program. Denver, Colorado. 9 pp.
- Day, K., and T. Modde. 1999. Distribution and recapture of razorback sucker stocked in the Middle Green River in 1995. Final report to the Recovery Implementation Program for the Endangered Fishes of the Upper Colorado River Basin. Recovery Program Project Number 29. Denver, Colorado. 20 pp.
- Foster, D. K., and G. Mueller. 1999. Movement patterns, behavior, and habitat use of razorback sucker stocked into the Green River at Canyonlands National Park, Utah. USGS Open File Report 99–107, Midcontinent Ecological Science Center, Fort Collins, Colorado.
- Gutermuth, F. B., L. D. Lentsch, and K. R. Bestgen. 1994. Collection of Age-0 razorback suckers (*Xyrauchen texanus*) in the lower Green River, Utah. Southwestern Naturalist 39: 389–391.
- Holden, P. B., C. Richard, L. W. Crist, and J. R. Campbell. 1981. Aquatic biology studies for proposed Colorado-Ute Electrical Association power plant near Grand Junction, Colorado. PR 56–1. December 1981. 66 pp.
- Holden, P. B., P. D. Abate, and J. B. Ruppert. 1997. Razorback sucker studies on Lake Mead, Nevada, 1996–1997 Annual Report, PR–578–1. Bio/West, Inc. Logan, Utah.
- Hudson, M., K. W. Wilson, L. D. Lentsch, and K. D. Christopherson. 1999. State of Utah stocking plan for endangered fish species in the Upper Colorado River Basin. Utah Division of Wildlife Resources, Salt Lake City. Publication Number 99–27. 53 pp.
- Hudson, M. 2001. State of Utah stocking plan for endangered fish species of the Upper Colorado River Basin. Revised Plan. Utah Division of Wildlife Resources, Salt Lake City. Publication Number 01–22. 14 pp.

- Marsh, P. C. 1994. Abundance, movements, and status of adult razorback sucker, *Xyrauchen texanus*, in Lake Mohave, Arizona and Nevada. *Proceedings of the Desert Fishes Council* 25:35.
- Marsh, P. C. 1997. Razorback sucker monitoring in Lake Mohave, Arizona-Nevada, for the period 01 November to 31 October 1996. Submitted to BOR (Contract 1425-97-PG-30-06390), Arizona State University, Center for Environmental Studies, Tempe.
- Marsh, P. C., and D. R. Langhorst. 1988. Feeding and fate of wild larval razorback sucker. *Environmental Biology of Fishes* 21:59-67.
- Marsh, P. C., and J. E. Brooks. 1989. Predation by ictalurid catfishes as a deterrent to re-establishment of hatchery-reared razorback suckers. *The Southwestern Naturalist* 34: 188-195.
- Martinez, A. M. 2001. Removal and control of nonnative fishes in the Colorado and Gunnison river floodplain source ponds. Annual report prepared for the Recovery Implementation Program for the Endangered Fishes of the Upper Colorado River Basin. Recovery Program Project Number C-18/19 and PIP 10. Colorado Division of Wildlife, Grand Junction.
- Martinez, A. M. 2002. Removal and control of nonnative fishes in the Colorado and Gunnison river floodplain source ponds. Annual report prepared for the Recovery Implementation Program for the Endangered Fishes of the Upper Colorado River Basin. Recovery Program Project Number C-18/19 and PIP 10. Colorado Division of Wildlife, Grand Junction.
- McAda, C. W. 1977. Aspects of the life history of three catostomids native to the upper Colorado River basin. Masters Thesis. Utah State University. 104 pp.
- McAda, C. W. 1997. Mechanical removal of northern pike from the Gunnison River, 1995-1996. Recovery Program Project Number 58. Final report prepared for the Recovery Implementation Program for Endangered Fishes in the Upper Colorado River Basin. U. S. Fish and Wildlife Service, Colorado River Fishery Project, Grand Junction, Colorado. 20 pp. + appendices.
- Meisner, S., and J. M. Hudson. 2001. Cyprinid removal in the lower Colorado and Green rivers. Annual report prepared for the Recovery Implementation Program for the Endangered Fishes of the Upper Colorado River Basin. Recovery Program Project No. 87a. Utah Division of Wildlife Resources, Moab.
- Minckley, W. L., P. C. Marsh, J. E. Brooks, J. E. Johnson, and B. L. Jensen. 1991. Management toward recovery of the razorback sucker. Pages 303-358 in W.L. Minckley and J.E. Deacon eds. *Battle against extinction*. University of Arizona Press, Tucson.

- Modde, T., K. P. Burnham, and E. J. Wick. 1996. Population status of the razorback sucker in the middle Green River, (U.S.A.). *Conservation Biology* 10 (1):110-119.
- Modde, T., R. T. Muth, G. B. Haines. 2001. Floodplain wetland suitability, access, and potential use by juvenile razorback suckers in the middle Green River, Utah. *Trans. of the American Fisheries Society* 130:1095-1105.
- Mueller, G. 1995. A program for maintaining the razorback sucker in Lake Mohave. *American Fisheries Society Symposium* 15:795-804.
- Mueller, G., and P. C. Marsh. 1998. Post-stocking dispersal, habitat use, and behavioral acclimation of juvenile razorback suckers (*Xyrauchen texanus*) in two Colorado River reservoirs. USGS open file report 98-301.
- Mueller, G., P. C. Marsh, and G. W. Knowles. 1998. Distribution, migratory behavior, and habitat use of razorback sucker (*Xyrauchen texanus*) in Lake Mohave, Arizona-Nevada. Open File Report 98-252, Midcontinent Ecological Science Center, Ft. Collins, Colorado.
- Mueller, G., and D. K. Foster. 1999. A case for site acclimation in the reintroduction of the endangered razorback sucker (*Xyrauchen texanus*). USGS Open File Report 99-107, Midcontinent Ecological Science Center, Northern Arizona University, Flagstaff, Arizona.
- Muth, R. T., and six co-authors. 1998. Reproduction and early life history of razorback sucker in the Green River, Utah and Colorado, 1992-1996. Final Report. Recovery Implementation Program for the Endangered Fishes of the Upper Colorado River Basin. Recovery Program Project Number 34. Denver, Colorado. 62 pp.
- Nesler, T. P. 1998. Five-year stocking plan for endangered Colorado River fish species in Colorado. Colorado Division of Wildlife, Denver. 34 pp.
- Nesler, T. P. 2001. Stocking plan for endangered Colorado River fish species in Colorado. Colorado Division of Wildlife, Denver. 24 pp.
- Nesler, T. P., K. Christopherson, C. McAda, F. Pfeifer, and T. Czapla. 2002. An integrated stocking plan for razorback sucker, bonytail, and Colorado pikeminnow for the Upper Colorado River Endangered Fish Recovery Program. Draft. Recovery Implementation Program for the Endangered Fishes of the Upper Colorado River Basin. 10 pp.
- Osmundson, D. B. 2002. Monitoring the Colorado pikeminnow population in the mainstem Colorado River via periodic population estimates. Annual report prepared for the Recovery Implementation Program for the Endangered Fishes of the Upper Colorado River Basin. Recovery Program Project Number 22-A-2. U. S. Fish and Wildlife Service, Colorado River Fishery Project, Grand Junction, Colorado.

- Osmundson, D. B. 2003. Removal of non-native centrarchids from Upper Colorado River backwaters, 1999–2001: Summary of Results. Draft Report prepared for the Recovery Implementation Program for the Endangered Fishes of the Upper Colorado River Basin. Recovery Program Project Number 89. U. S. Fish and Wildlife Service, Colorado River Fishery Project, Grand Junction, Colorado.
- Osmundson, D. B., and L. R. Kaeding. 1989. Studies of Colorado squawfish and razorback sucker use of the "15-mile reach" of the upper Colorado River as part of conservation measures for the Green Mountain and Ruedi Reservoir water sales. Final Report. Colorado River Fishery Project, U. S. Fish and Wildlife Service, Grand Junction, Colorado. 85 pp.
- Osmundson, D. B., and L. R. Kaeding. 1991. Recommendations for flows in the 15-mile reach during October-June for maintenance and enhancement of endangered fish populations in the Upper Colorado River. Final Report. U. S. Fish and Wildlife Service, Colorado River Fishery Project, Grand Junction, Colorado. 82 pp.
- Pacey, C. A., and P. C. Marsh. 1998. Resource use by native and nonnative fishes of the lower Colorado River: Literature review, summary, and assessment of relative roles of biotic and abiotic factors in management of an imperiled indigenous ichthyofauna. Submitted to Bureau of Reclamation, Boulder City, Nevada, Contract 7-MT-30-R0012. Arizona State University, Tempe.
- Piper, R. and others. 1982. Fish hatchery management. United States Department of the Interior. Fish and Wildlife Service. Washington, D. C. 517 pp.
- Pitlick, J., and R. Cress. 2000. Longitudinal trends in channel characteristics of the Colorado River and implications for food-web dynamics. Final Report prepared for the Recovery Implementation Program for the Endangered Fishes of the Upper Colorado River Basin. Recovery Program Project Number 48-C. University of Colorado, Boulder. 45 pp + appendices.
- Pottinger, T. G., and A. D. Pickering. 1992. The influence of social interaction on the acclimation of rainbow trout, *Onchorhynchus mykiss* (Walbaum) to chronic stress. *Journal of Fish Biology* 41:435–447.
- Ryden, D. W. 1997. Five-year augmentation plan for razorback sucker in the San Juan River. Final Report. U. S. Fish and Wildlife Service, Colorado River Fishery Project, Grand Junction, Colorado. 27 pp.
- Ryden, D. W. 2000. Monitoring of experimentally stocked razorback sucker in the San Juan River: March 1994–October 1997. Final Report. U. S. Fish and Wildlife Service, Grand Junction, Colorado. 132 pp.

- Ryden, D. W. 2001. Monitoring of razorback sucker stocked into the San Juan River as part of a five-year augmentation effort: 2000 interim progress report (FINAL). U. S. Fish and Wildlife Service, Grand Junction, Colorado. 83 pp.
- Ryden, D. W., and Pfeifer, F. K. 1994. An experimental stocking plan for razorback sucker in the San Juan River. U. S. Fish and Wildlife Service, Grand Junction, Colorado. 26 pp.
- Ryden, D. W., and Pfeifer, F. K. 1995. Monitoring of experimentally stocked razorback sucker in the San Juan River: 1994 annual progress report. U. S. Fish and Wildlife Service, Grand Junction, Colorado. 30 pp.
- Ryden, D. W., and Pfeifer, F. K. 1996. Monitoring of experimentally stocked razorback sucker in the San Juan River: 1995 annual progress report. U. S. Fish and Wildlife Service, Grand Junction, Colorado. 37 pp.
- Taba, S. S., J. R. Murphy, and H. H. Frost. 1965. Notes on the fishes of the Colorado River near Moab, Utah. Proceedings of the Utah Academy of Sciences, Arts, and Letters 42 (II): 280-283.
- Trammell, M., Valdez, R., H. Johnstone, and L. Jonas. 2002. Non-native fish control in backwater habitats in the Colorado River. Final report by SWCA, Inc. to Upper Colorado River Endangered Fish Recovery Program. Recovery Program Project Number 87b. U. S. Fish and Wildlife Service, Denver, Colorado. 43 pp. + appendix.
- Tyus, H. M. 1987. Distribution, reproduction, and habitat use of the razorback sucker in the Green River, Utah, 1979-1896. Transactions of the American Fisheries Society 116:11-116.
- Tyus, H. M., R. L. Jones, and L. A. Trinca. 1987. Green River rare and endangered fish studies, 1982-85. U. S. Fish and Wildlife Service, Vernal, Utah. 117 pp.
- Tyus, H. M., and C. A. Karp. 1989. Habitat use and streamflow needs of rare and endangered fishes, Yampa River, Colorado. Biological Report 89(14). U. S. Fish and Wildlife Service, Denver, Colorado.
- Tyus, H. M., and C. A. Karp. 1990. Spawning and movements of razorback sucker, *Xyrauchen texanus*, in the Green River basin of Colorado and Utah. The Southwestern Naturalist. 35(4):427-433.
- U. S. Fish and Wildlife Service (FWS). 1998. Razorback sucker (*Xyrauchen texanus*) recovery plan. Denver, Colorado. 81 pp.
- U. S. Fish and Wildlife Service (FWS). 2002. Recovery goals for razorback sucker (*Xyrauchen texanus*) of the Colorado River Basin. A supplement and amendment to the razorback sucker recovery plan. U. S. Fish and Wildlife Service, Denver, Colorado. 78 pp + appendices.

- Valdez, R. A., P. G. Mangan, R. P. Smith, and B. Nilson. 1982. Upper Colorado River investigations. Pages 101–279 in W. H. Miller et al., editors. Colorado River Fishery Project, Final Report: Part Two, Field Studies, U. S. Fish and Wildlife Service and Bureau of Reclamation, Salt Lake City, Utah.
- Williamson, J. H. 2001. Broodstock management for imperiled and other fishes. Pages 397–482 in G. A. Wedemeyer, editor. Fish hatchery management, second edition. American Fisheries Society, Bethesda, Maryland.
- Williamson, J. H., and R. S. Wydoski. 1994. Genetics management guidelines. Recovery Implementation Program for Endangered fishes in the Upper Colorado River Basin. U. S. Fish and Wildlife Service, Denver, Colorado.
- Wydoski, R. S. 1994. Coordinated hatchery facility plan: need for captive-reared endangered fish and propagation facilities. Recovery Implementation Program for Endangered fishes in the Upper Colorado River Basin. U. S. Fish and Wildlife Service, Denver, Colorado. 133 pp.
- Wydoski, R. S. 1995. Genetics management plan. Recovery Implementation Program for Endangered fishes in the Upper Colorado River Basin. U. S. Fish and Wildlife Service, Denver, Colorado.
- Wydoski, R. S. 1996. Augmentation plan for razorback sucker in the middle Green River, 1996–1997. Recovery Implementation Program for Endangered fishes in the Upper Colorado River Basin. U. S. Fish and Wildlife Service, Denver, Colorado.

APPENDIX A
Breeding and Parental Lineage of Family Lots
Produced: 1992-2000

Table A.1. Summary of lineage and the number of family lots produced from broodstock used for razorback sucker that were stocked in the Upper Colorado and Gunnison rivers from October 1995 through October 2001. See Appendix; Tables C.1.-C.7. for the number of fish stocked into each river by date, location, year-class, and family lot.

Spawning Year (Year-Class)	Total Number of Fish Used	Parental Lineage & Source	Number of Family Lots Stocked	Rearing Location
1992	7	All Wild Fish : 8 crosses 7 San Juan River Arm of Lake Powell (4 males, 3 females)	6	Wahweap SFH, UT
1993	0	----	----	
1994	7	All Wild Fish: 6 crosses 2 Grand Valley males + 1 Grand Valley female; 1 Etter Pond female 3 Colorado River Arm of Lake Powell (2 males, 1 female)	4 2	Bellvue SFH, CO Ouray NFH, UT
1995	16	All Wild Fish: 19 crosses 1 Grand Valley male + 2 Grand Valley females; 2 Colorado River Arm Lake Powell males + 2 Colorado River Arm of Lake Powell females; 4 San Juan River Arm of Lake Powell males + 3 San Juan River Arm of Lake Powell females; 2 Etter Pond females	16	Valley City NFH Valley City, ND Wahweap, SFH, UT
1996	7	Wild Fish (6) + F ₁ (1): 5 crosses 1 San Juan River Arm of Lake Powell male (F ₁); 1 Etter Pond male; 3 Grand Valley females; 2 Colorado River Arm of Lake Powell females	5	Clymer Pond & 24 Rd Hatchery, Grand Junction
1997	8	Wild Fish (6) + F ₁ (2): 4 crosses 2 San Juan River Arm of Lake Powell males (F ₁) 1 San Juan River Arm of Lake Powell male + 1 San Juan River Arm of Lake Powell female 2 Grand Valley females; 1 Colorado River Arm of Lake Powell male; 1 Etter Pond male	4	24 Rd Hatchery, Grand Junction
1998	17	Wild Fish (8) + F ₁ (9): 12 crosses 5 San Juan River Arm of Lake Powell males (F ₁) + 4 San Juan River Arm of Lake Powell females (F ₁); 2 San Juan River Arm of Lake Powell males + 1 San Juan River Arm of Lake Powell female; 1 Grand Valley male; 1 Colorado River Arm of Lake Powell female; 2 Etter Pond females; 1 Green River male	10	24-Rd Hatchery & 4 grow-out ponds in the Grand Valley, Grand Junction

Table A.1.(cont'd).

Spawning Year (Year- Class)	Total Number of Fish Used	Parental Lineage & Source	Number of Family Lots Stocked	Rearing Location
1999	41	Wild Fish (13) + F ₁ (28): 30 crosses 6 1992 year-class San Juan River Arm of Lake Powell females (F ₁) + 5 1992 year-class San Juan River Arm of Lake Powell males (F ₁); 1 1994 year-class female (F ₁); 5 1995 year-class females (F ₁) + 7 1995 year-class males (F ₁); 4 Green River males (F ₁); 2 Etter Pond females; 3 Grand Valley males; 1 Colorado River Arm of Lake Powell female; 3 Green River females + 2 Green River males; 1 San Juan River Arm of Lake Powell female + 1 San Juan River Arm of Lake Powell male	22	24-Rd Hatchery & 13 grow-out ponds in the Grand Valley, Grand Junction
2000	50	Wild Fish (13) + F ₁ (37): 33 crosses 5 1991 Green River 1991 year-class females (F ₁) + 5 1991 Green River 1991 year-class males (F ₁); 4 1992 year-class females (F ₁) + 8 1992 year-class males (F ₁); 6 1994 year-class females (F ₁) + 4 1994 year-class males (F ₁); 3 1995 year-class females (F ₁) + 2 1995 year-class males (F ₁); 2 Etter Pond females; 4 Green River females + 5 Green River males; 1 San Juan River Arm of Lake Powell female; 1 Grand Valley male	12	24-Rd Hatchery & 18 grow-out ponds in the Grand Valley, Grand Junction

Table A.2. Breeding matrix and paired matings of wild razorback sucker used for producing 46 family lots from 1992–2000. Year-class and family lot of fish produced from each mating are provided in individual boxes of the table. For example, 9511 refers to the year class (1995) and the second number or letter refers to the family lot (11 or C). Family lots of razorback sucker produced in these matings were stocked in the Upper Colorado and Gunnison rivers and some were retained to increase the number of razorback sucker broodstock (F_1). These F_1 fish were later crossed with wild razorback sucker broodfish and other F_1 fish to produce additional family lots for stocking and future broodfish (F_2 ; personal communication, Mike C. Baker, U. S. Fish and Wildlife Service). Additional paired matings produced from F_1 broodstock are available from the CRFP, Fish and Wildlife Service office in Grand Junction, Colorado.

MALES												
	A	B	C	D	E	F	G	H	I	J	K	L
1								922A				
2					921C			921A	922B			
3		9609										
4	9511		9512		9513							
5	9507	9610	94-E	94-F								
6	94-C	94-D	9501		9701							
7	94-A	94-B										
8				9516		9517	9518					9806
9	9802	9601		9519	9801	9520	9521				9908	9907
10	9803			9522	9805	9523	9804					
11	9515	9703		9525				923A				9913
12							9915					
13	9911						9912					
14	2003									9921		
15	9914											

FEMALES	MALES												
		A	B	C	D	E	F	G	H	I	J	K	L
	1								922A				
	2					921C			921A	922B			
	3		9609										
	4	9511		9512		9513							
	5	9507	9610	94-E	94-F								
	6	94-C	94-D	9501		9701							
	7	94-A	94-B										
	8				9516		9517	9518					9806
	9	9802	9601		9519	9801	9520	9521				9908	9907
	10	9803			9522	9805	9523	9804					
	11	9515	9703		9525				923A				9913
	12							9915					
	13	9911						9912					
	14	2003									9921		
	15	9914											

Males: A=GVF7E, B=EP360, C=CRD78, D=CR363, E=SJ964, F=SJC29, G=SJ07A, H=SJ802, I=SJ000, J=GRC33, K=GR906, L=GRF23

Females: 1=SJ36C, 2=SJB63, 3=GVC6B, 4=SJ870, 5=CR81D, 6=GV436, 7=GV914, 8=EP06D, 9=CR275, 10=EP404, 11=SJ75F, 12=GR06B, 13=GRF0A, 14=GR575, 15=GR768

Source of Fish: GV=Grand Valley (river mile 185.3–152.6) near Grand Junction (Colorado River); EP=Etter Pond near Debeque, CO (Colorado River); CR= Colorado River arm of Lake Powell; SJ=San Juan River arm of Lake Powell; GR=Green River

APPENDIX B
Sampling Dates and Locations: 1995–2001

Table B.1. River miles and dates sampled with electrofishing and seines for stocked razorback sucker on the Gunnison (GU) and Upper Colorado (CO) rivers from October 1995 through September 2001. Electrofishing was conducted from outboard motor-powered aluminum, jon boats and oar-driven rubber rafts. Electrofishing effort was actual time that an electrical circuit was transmitted into the water. Seines used were 6 mm bar mesh, 9 m long X 1.8 m deep.

Year	River	River Miles Sampled	Dates Sampled	Seining		Electrofishing	
				Area Swept (m ²)	No. of Hauls	Effort (h)	No. of Boats
1995	GU	59.3 – 4.8	10/18–11/02	8,584	55	--	--
1996	GU	57.0– 50.3	10/07	---	---	3.9	2
		50.3– 42.7	10/08	---	---	2.2	1
		42.7– 29.3	10/09	---	---	2.8	1
		32.8– 30.4	10/09	---	---	0.6	1
		57.0– 50.3	10/10	---	---	1.9	1
1997	GU	57.0– 4.1	07/28–08/01	---	---	44.5	2
1998	GU	57.0– 4.1	08/03–08/07	---	---	35.6	2
		57.0– 42.1	09/08	---	---	3.9	1
		57.0– 42.7	10/07	---	---	3.9	1
		42.7– 29.3	08/27	---	---	2.8	1
		42.7– 29.3	09/30	---	---	2.8	1
		29.3– 14.7	09/09	---	---	2.2	1
		29.3– 14.7	10/05	---	---	2.2	1
		14.7– 3.9	10/05	---	---	1.9	1
1999	GU	57.0– 4.1	07/26–07/29	---	---	38.9	2
		57.0– 4.1	09/13–09/16	---	---	32.8	2
2000	CO	240.7–195.7	07/10–07/14	---	---	31.8	2
	GU	57.0– 4.1	08/01–08/04	---	---	37.5	2
		57.0– 4.1	09/05–09/08	---	---	34.1	2
2001	CO	240.7–195.7	07/16	---	---	38.0	2
			07/18–07/20				
			07/27				
		187.6–185.4	07/17				
		177.4–128.0	07/24–07/26				
			07/19				
	GU	57.0– 4.1	08/09–08/12	---	---	28.5	2
		57.0– 4.1	09/04–09/07	---	---	32.6	2
		3.0– 0.7	07/18	---	---	2.1	1

APPENDIX C
Number and Length Statistics of Razorback Sucker
Stocked in the Upper Colorado and Gunnison Rivers:
1994-2001

Table C.1. Number and length statistics of razorback sucker stocked into the Gunnison River, April 1994 and September and October 1995.

Source Date Stocked	Stocking Location		Number of Fish Stocked	Total Length Stocked (mm)		Year Class Stocked	No. of Family Lots Stocked
	River	River Mile		Mean	Range		
Etter Pond (Debeque) *							
04/06/94	CO	211.1	6	502	451-534	???	--
		220.9	7				
		228.8	7				
04/07/94	GU	51.5	7	494	455-536	???	--
		53.5	7				
		59.4	7				
09/13/95	GU	53.6	4	480	459-526	???	--
Horsethief Ponds							
10/13/95	GU	57.0	316	123	83-210	1994	5

* razorback sucker captured from Etter Pond were all surgically implanted with radio transmitters.

Table C.2. Number and length statistics of razorback sucker stocked into the Gunnison River, October 1996.

Source Date Stocked	Stocking Location		Number of Fish Stocked	Total Length Stocked (mm)		Year Class Stocked	No. of Family Lots Stocked
	River	River Mile		Mean	Range		
Wahweap Ponds (Utah)							
10/04	GU	57.0	282	343	230-408	1992	8

Table C.3. Number and length statistics of razorback sucker stocked into the Gunnison River, September 1997.

Source Date Stocked	Stocking Location		Number of Fish Stocked	Total Length Stocked (mm)		Year Class Stocked	No. of Family Lots Stocked
	River	River Mile		Mean	Range		
24 Road Hatchery 09/12, 14, 15, 17, 26; 10/14	GU	57.0	2,147	176	102-296	1995	6
Clymer's Pond 09/14, 15, 17, 26 10/14	GU	57.0	1,294	230	95-345	1995	7
Wahweap Ponds (Utah) 09/25	GU	57.0	291	399 ^b	---	1995	14

^b mean total length at stocking was determined to be 399 mm from 30 representative fish.

Table C.4. Number and length statistics of razorback sucker stocked into the Gunnison River, June, September, and October 1998.

Source Date Stocked	Stocking Location		Number of Fish Stocked	Total Length Stocked (mm)		Year Class Stocked	No. of Family Lots Stocked
	River	River Mile		Mean	Range		
24 Road Hatchery 06/23	GU	57.0	233	218	75-323	1997	3
09/01	GU	57.0	249	222	107-334	1997	3
10/29	GU	57.0	126	414	325-493	1997	16

Table C.5. Number and length statistics of razorback sucker stocked into the Gunnison (GU) and Colorado (CO) rivers, May, August, September, October, and November 1999.

Source Date Stocked	Stocking Location		Number of Fish Stocked	Total Length Stocked (mm)		Year Class Stocked	No. of Family Lots Stocked
	River	River Mile		Mean	Range		
29 Road Pond							
08/03	GU	57.0	289	190	127-271	1998	2
08/04	GU	57.0	150	196	153-275	1998	2
08/05	GU	57.0	703	174	128-275	1998	2
08/06	GU	57.0	322	173	145-246	1998	2
08/10	GU	57.0	268	172	146-235	1998	2
09/22	CO	227.0	1,539	169	111-283	1998	2
10/26	CO	227.0	707	174	117-281	1998	2
Dike Road Pond							
09/08	GU	57.0	224	185	136-278	1998	2
09/09	GU	57.0	211	178	134-251	1998	2
09/10	GU	57.0	120	173	132-247	1998	2
10/29	CO	227.0	723	154	106-286	1998	2
Clymer's Pond							
09/24	CO	227.0	274	212	135-310	1998	1
10/26	CO	227.0	53	210	148-281	1998	1
10/29	CO	227.0	46	211	156-265	1998	1
11/04	GU	57.0	455	211	129-282	1998	1
Highline Ponds (3)							
09/24	CO	227.0	156	181	117-252	1998	6
Horsethief Ponds (Broodfish)							
05/10	GU	57.0	30	447	355-495	1995	12

Table C.6. Number and length statistics of razorback sucker stocked into the Gunnison (GU) and Colorado (CO) rivers, April, August, September, October, and November 2000.

Source Date Stocked	Stocking Location		Number of Fish Stocked	Total Length Stocked (mm)		Year Class Stocked	No. of Family Lots Stocked
	River	River Mile		Mean	Range		
19 Road Pond							
09/15	CO	177.4	101	192	132-270	1999	1
09/14	CO	177.4	156	196	136-276	1999	1
11/07	CO	177.4	98	200	109-287	1999	1
24 Road Hatchery							
04/15	CO	227.0	2,085	118	85-194	1999	2
04/19	CO	220.9	933	121	90-300	1999	2
04/21	CO	220.9	2,042	125	77-291	1999	2
08/10	CO	220.9	2,008	170	?? - ??	1999	18
09/07	CO	177.4	6,330	122	113-136	1999	9
10/12	CO	177.4	440	159	117-262	1999	1
10/31	GU	57.0	2,104	145	104-211	1999	4
11/20	CO	220.9	3,942	137	78-190	1999	8
29 Road Pond							
08/21	GU	57.0	804	195	104-334	1998/1999	Various Mixed Lots
08/22	CO	220.9	611	178	101-334	1998/1999	
08/23	GU	57.0	285	177	98-312	1998/1999	
08/24	CO	220.9	137	166	88-295	1998/1999	
09/25	CO	220.9	169	202	85-340	1998/1999	
09/26	CO	220.9	93	201	121-317	1998/1999	
Clymer's Pond							
08/24	CO	220.9	1,011	208	123-324	1999	1
08/25	GU	57.0	381	213	164-326	1999	
09/11	CO	177.4	1,269	227	138-345	1999	
09/12	CO	177.4	523	225	169-328	1999	
09/13	CO	177.4	332	223	104-309	1999	
10/26	CO	177.4	339	208	102-320	1999	
10/27	CO	177.4	319	211	110-333	1999	
10/30	GU	57.0	180	213	108-300	1999	
10/31	GU	57.0	21	211	150-274	1999	
11/03	GU	57.0	478	216	129-344	1999	
Devils Canyon 2 Pond							
09/27& 09/28& 09/29	CO	177.4	155	197	130-280	1999	1

Table C.6. (cont'd).

Source Date Stocked	Stocking Location		Number of Fish Stocked	Total Length Stocked (mm)		Year Class Stocked	No. of Family Lots Stocked
	River	River Mile		Mean	Range		
Dike Road Pond							
08/23&	GU	57.0	130				
08/24&	CO	220.9	108	177	114-328	1999	1
08/25	GU	57.0	37				
Elam Pond							
09/25&							
09/26	CO	177.4	247	249	146-327	1999	1
Heuton Pond							
10/30&							
10/31&	GU	57.0	534	204	90-289	1999	1
11/01							
Highline 1							
10/27	CO	177.4	8	254	191-307	1999	1
Morse Pond							
09/19	CO	220.9	1,538	211	112-328	1999	
09/20	GU	57.0	877	205	120-308	1999	
09/21	GU	57.0	463	197	130-358	1999	1
09/22	CO	177.4	246	197	128-313	1999	
Peters 1 Pond							
11/09	CO	177.4	39	219	144-284	1999	1
Peters 2 Pond							
11/07&							
11/09	CO	177.4	304	201	135-294	1999	1
Peters 3 Pond							
11/02&	GU	57.0	331	240	150-341	1999	1
11/09	CO	177.4	29	225	193-320	1999	1
Peters 4 Pond							
10/12	CO	177.4	209	153	108-290	1999	1

Table C.7. Number and length statistics of razorback sucker stocked into the Gunnison (GU) and Colorado (CO) rivers, April, May, June, July, August, September, and October 2001.

Source Date Stocked	Stocking Location		Number of Fish Stocked	Total Length Stocked (mm)		Year Class Stocked	No. of Family Lots Stocked
	River	River Mile		Mean	Range		
19 Road Pond 09/25	CO	177.4	35	253	172-338	2000	1
24 Road Hatchery 05/17	CO	229.9	60	272	170-360	1999	Various Mixed Lots
29 Road Pond 08/22	GU	57.0	147	310	233-430	1999	1
						2000	1
08/23	CO	226.5	80	317	218-388	1999	1
						2000	1
Clymer's Pond 08/23, 24	CO	177.4	1,344	234	163-358	2000	1
09/18;	GU	57.0					
10/24, 25	CO	226.5					
09/17, 19	GU	57.0	419	233	185-311	2000	1
McGuire Pond 09/10	GU	57.0	254	248	164-346	2000	1
Selenium Study 04/03	GU	57.0	55	--	---	1992	1
Roehmer Pond 08/01	CO	226.5	37	294	265-326	1999	1
Broodstock 06/12, 21	GU	57.0	64	463	342-586	1991/1995/ Wild/ SJRALP/ CRALP*	Various Mixed Lots
Broodstock 07/19	GU	57.0	35	456	392-579	1992	5
Morse Pond 09/10, 11	GU	57.0	398	338	190-422	1999	2
Dike Road Pond 09/18	GU	57.0	101	256	122-373	2000	1

Table C.7. (cont'd).

Source Date Stocked	Stocking Location		Number of Fish Stocked	Total Length Stocked (mm)		Year Class Stocked	No. of Family Lots Stocked
	River	River Mile		Mean	Range		
Heuton Pond 09/26	GU	57.0	150	234	165-305	2000	1
Peters 1 Pond 10/04, 22	GU	57.0	448	240	186-323	2000	1
10/23	CO	226.5	54	227	185-281	2000	1
Peters 2 Pond 09/21; 10/02, 21	GU	57.0	555	217	127-286	2000	1
Peters 3 Pond 10/01	GU	57.0	490	224	186-327	2000	1
Peters 4 Pond 09/19, 20, 21; 10/01	GU	57.0	599	281	198-380	1999	Various Mixed Lots
09/20	GU	57.0	46	230	157-297	2000	1
10/02	CO	177.4	62	264	155-335	1999	Various Mixed Lots
Debeque Ponds # 3, # 7 10/03, 05	CO	226.5	312	267	160-378	2000	2
Debeque Ponds # 5, # 6, # 8 10/05, 09, 11	GU	57.0	385	254	112-360	2000	3
Tomlinson Pond 10/23, 24	CO	226.5	130	258	147-370	2000	Various Mixed Lots

* SJRALP=San Juan River Arm of Lake Powell
CRALP=Colorado River Arm of Lake Powell

Table C.8. Length frequency by 25-mm class increments for razorback sucker stocked in the Gunnison River from April 1994 to September 2001 and in the Colorado River from September 1999 to October 2001. Refer to Appendix; Figures C.1–C.7. for year-by-year breakdown of razorback sucker stocked by river.

<u>Total Length Class</u>		<u>No. of Razorback sucker Stocked</u>	<u>Percentage</u>
<u>(mm)</u>	<u>[approx. inches]</u>		
< 75	3	0	--
75– 99		419	1.0
100–124	4 – 5	7,023	16.7
125–149		6,770	16.1
150–174	6 – 7	5,671	13.5
175–199		5,560	13.2
200–224	8 – 9	6,257	14.9
225–249		4,305	10.2
250–274	10–11	2,583	6.1
275–299		1,431	3.4
300–324	12–13	646	1.5
325–349		324	0.8
350–374	14–15	295	0.7
375–399		450	1.1
400–424	16–17	92	0.2
425–449		63	0.1
450–474	18–19	60	0.1
475–499		35	< 0.1
500–524	20–21	18	< 0.1
525–549		15	< 0.1
550–574	22–23	1	< 0.1
575–599		5	< 0.1
> 599	24	0	--
Totals		42,023	100.0

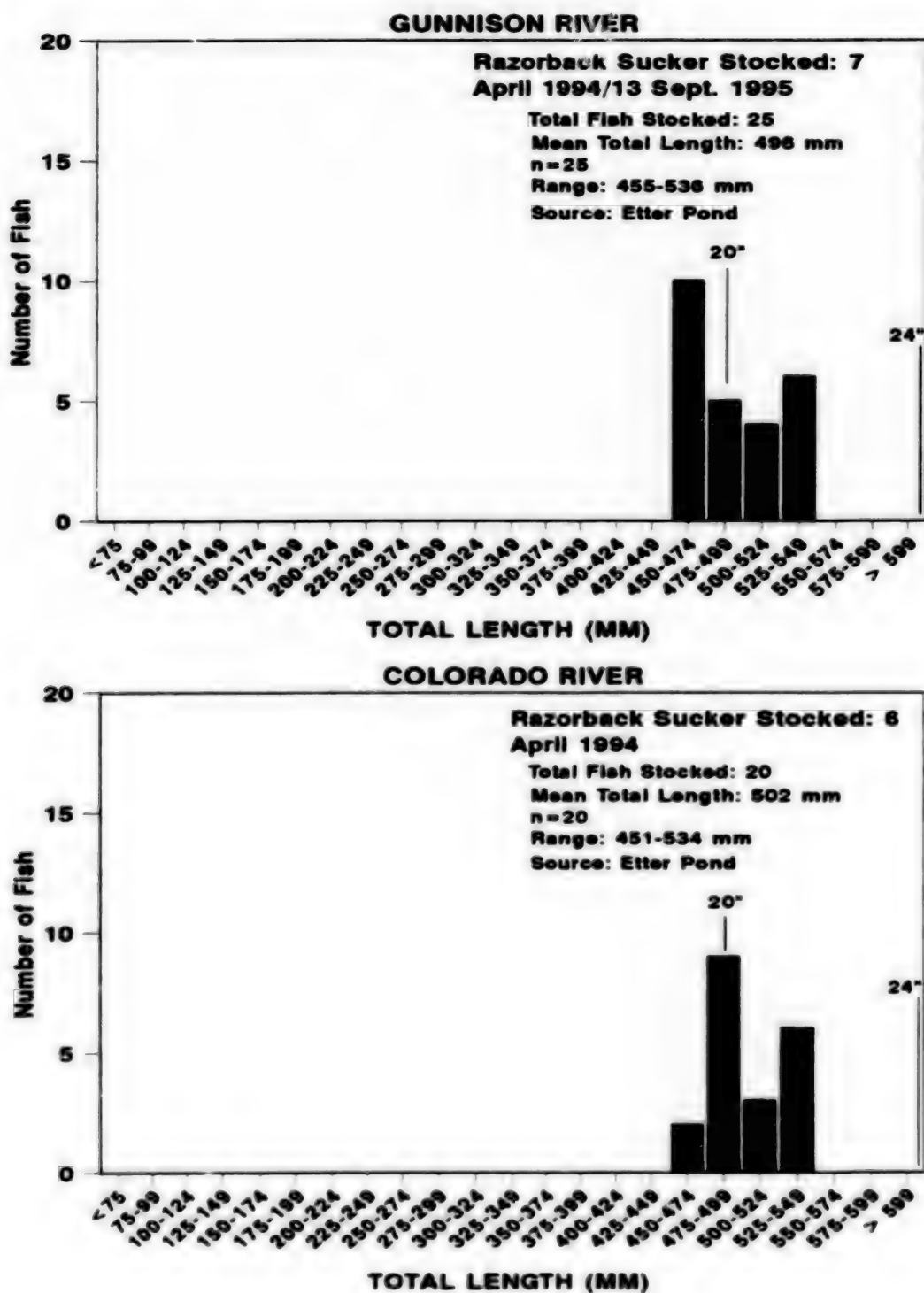


Figure C.1. Length-frequency distribution of razorback sucker stocked into the Gunnison River in April 1994 and September 1995 (top) and into the Colorado River in April 1994 (bottom). Fish were captured from Etter Pond near Debeque, CO.

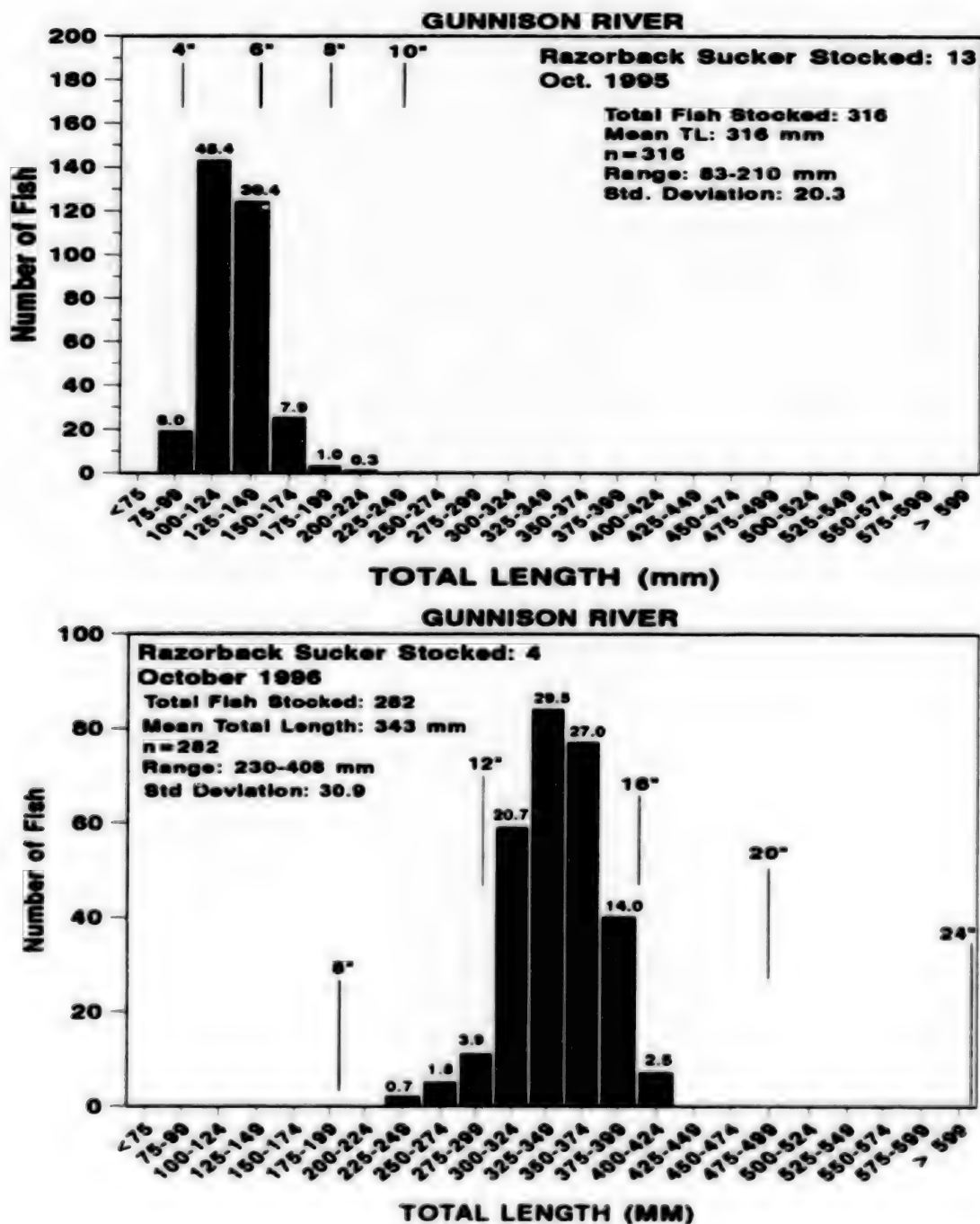


Figure C.2. Length-frequency distribution of razorback sucker stocked into the Gunnison River on 13 October 1995 (top) and on 4 October 1996 (bottom). Note: numbers above the bars represent percent.

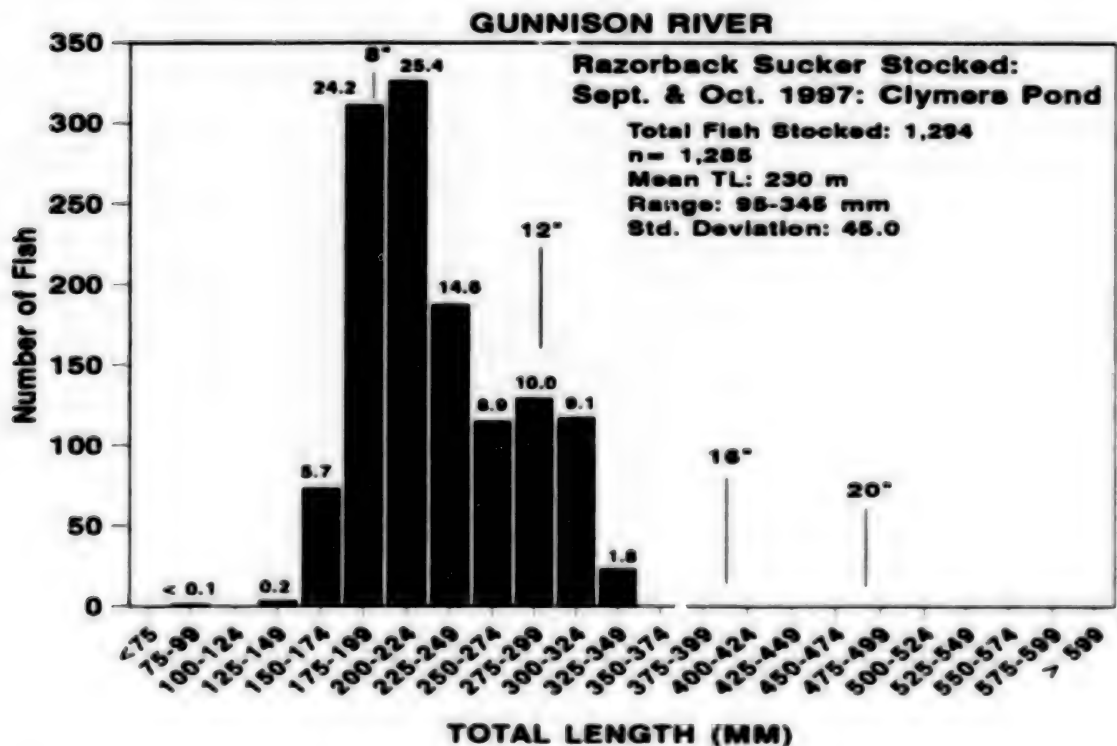
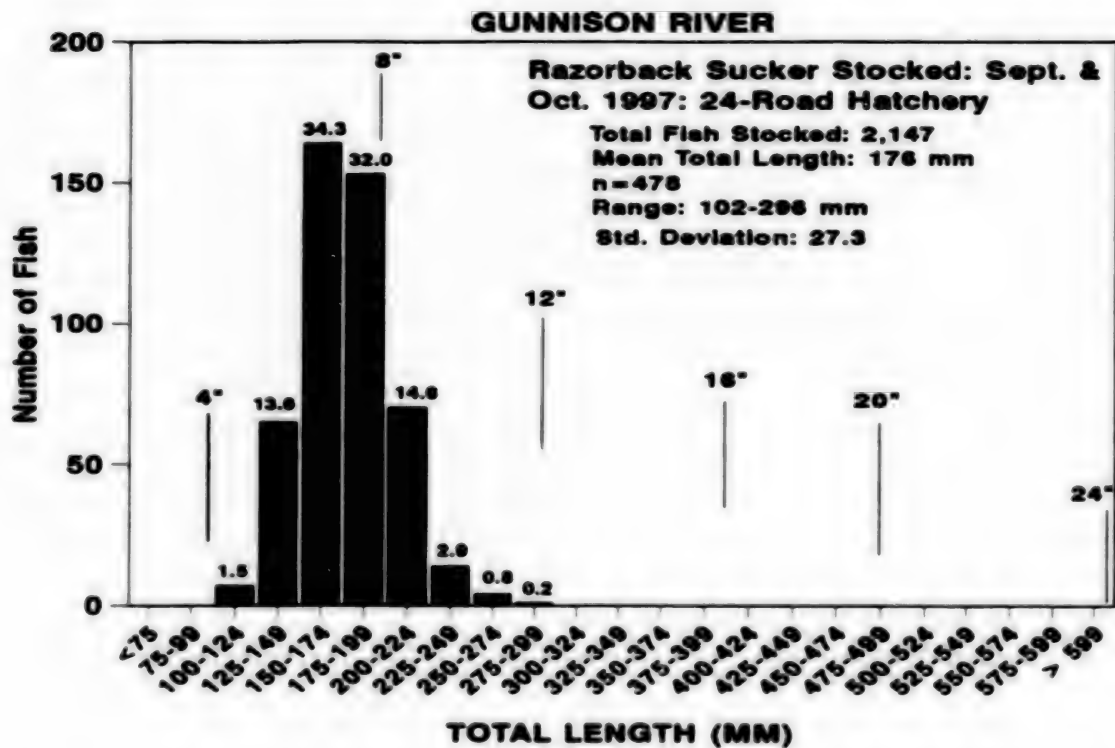


Figure C.3. Length-frequency distribution of razorback sucker stocked into the Gunnison River during September and October 1997. Note: numbers above the bars represent percent.

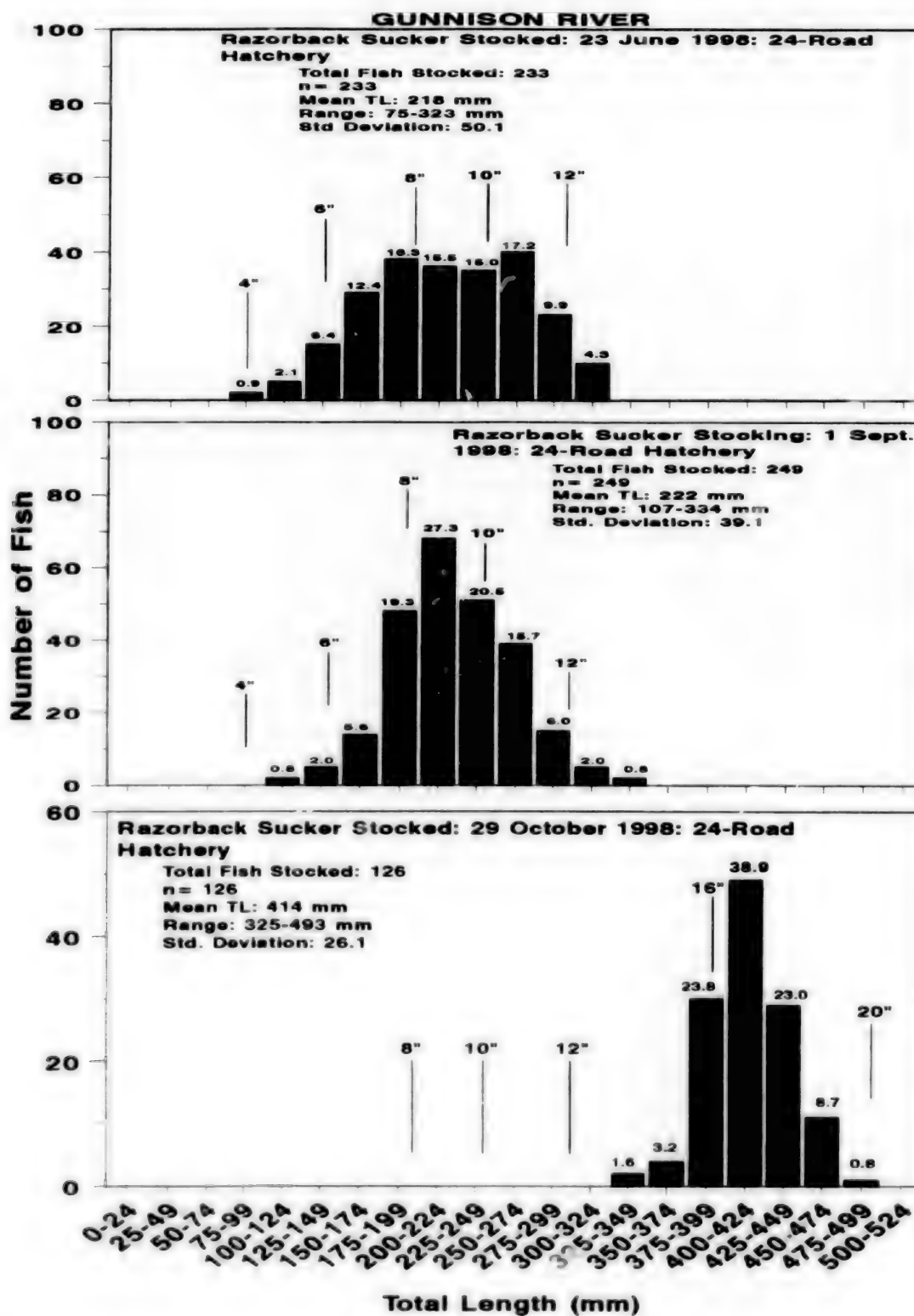


Figure C.4. Length-frequency distribution of razorback sucker stocked into the Gunnison River during 1998. Note: numbers above the bars represent percent.

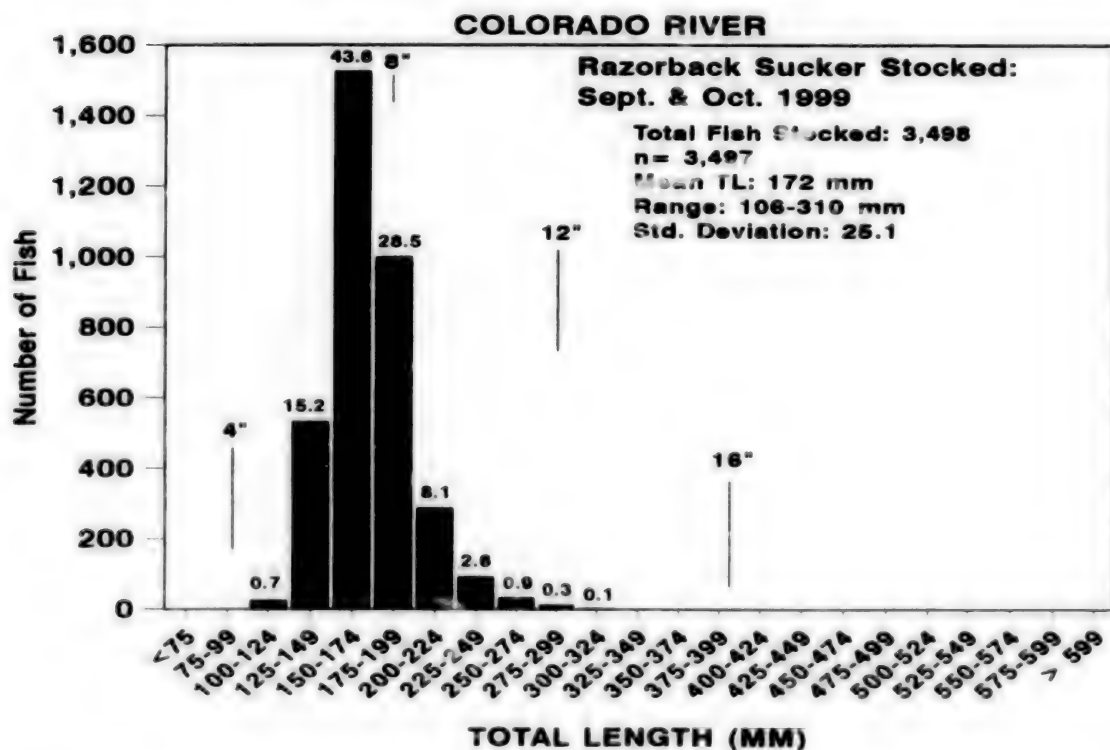
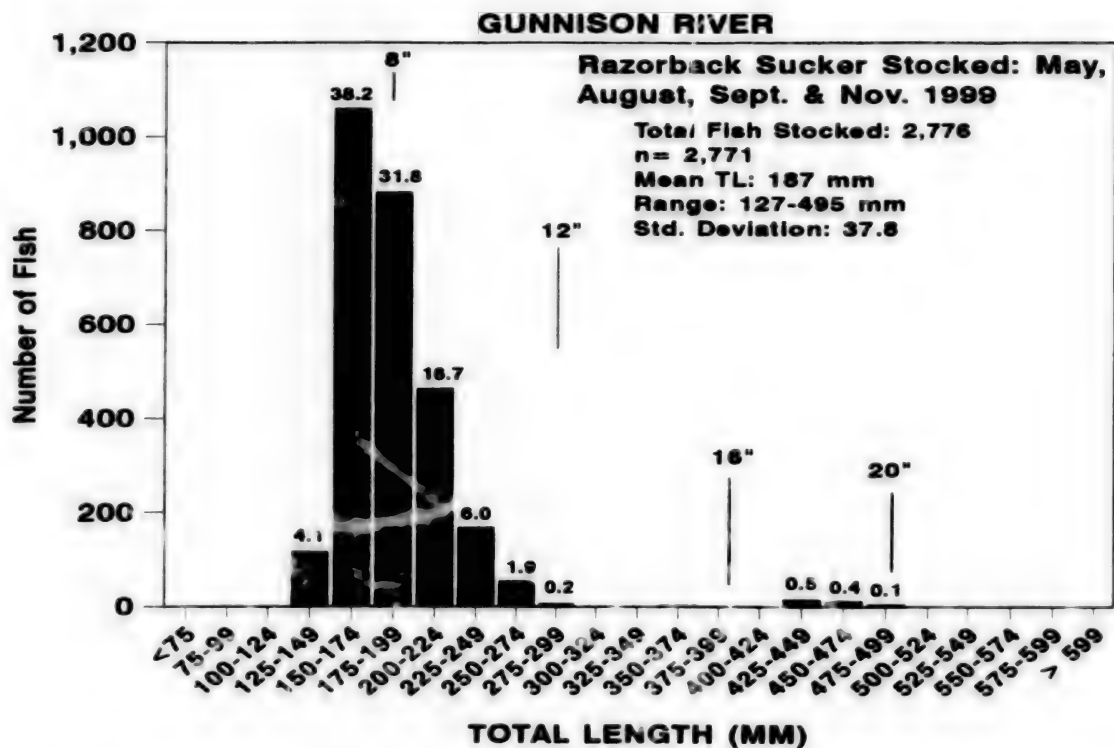


Figure C.5. Length-frequency distribution of razorback sucker stocked into the Gunnison (top) and Colorado (bottom) rivers during 1999. Note: numbers above the bars represent percent.

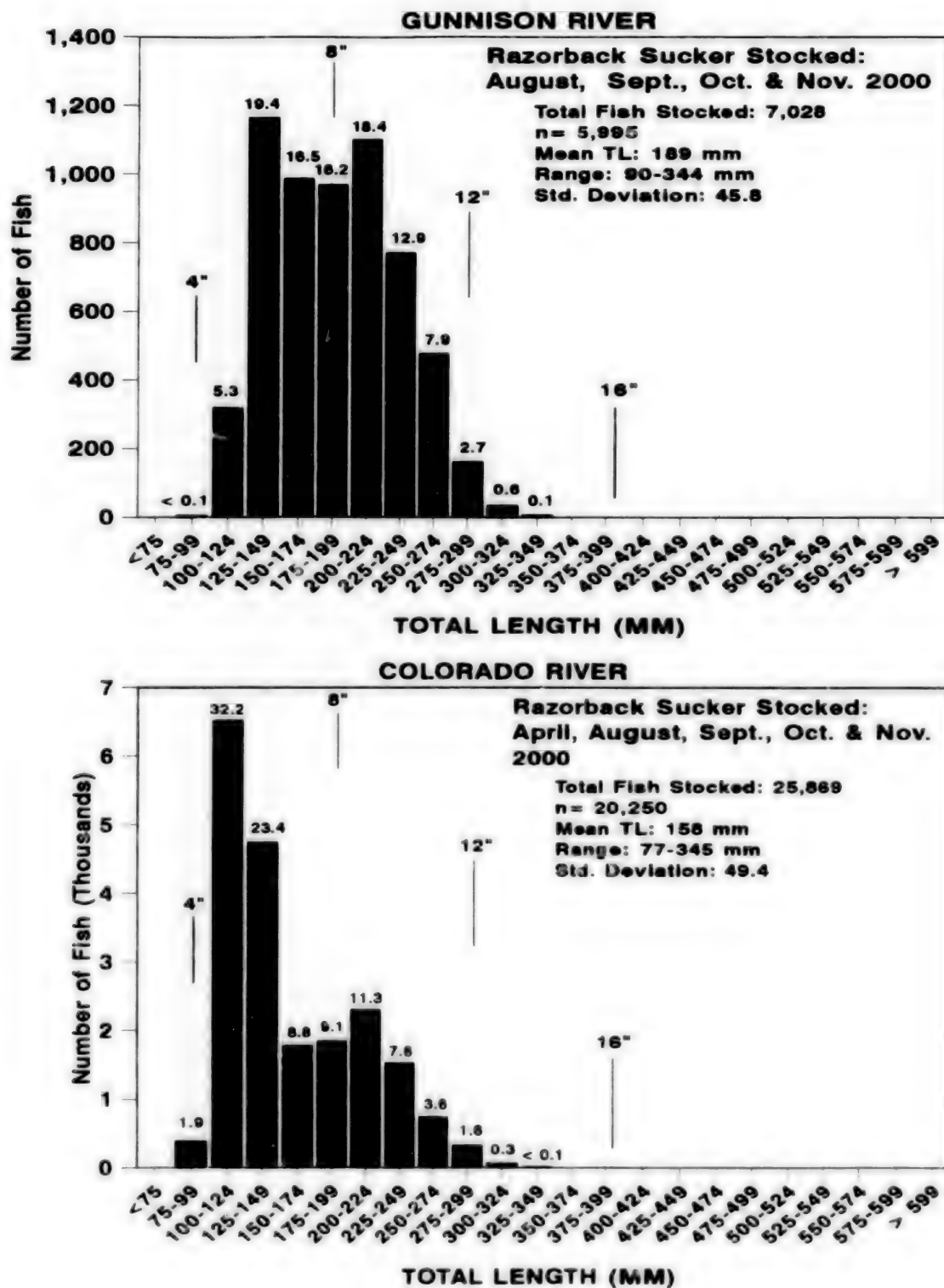


Figure C.6. Length-frequency distribution of razorback sucker stocked into the Gunnison (top) and Colorado (bottom) rivers during 2000. Note: numbers above the bars represent percent.

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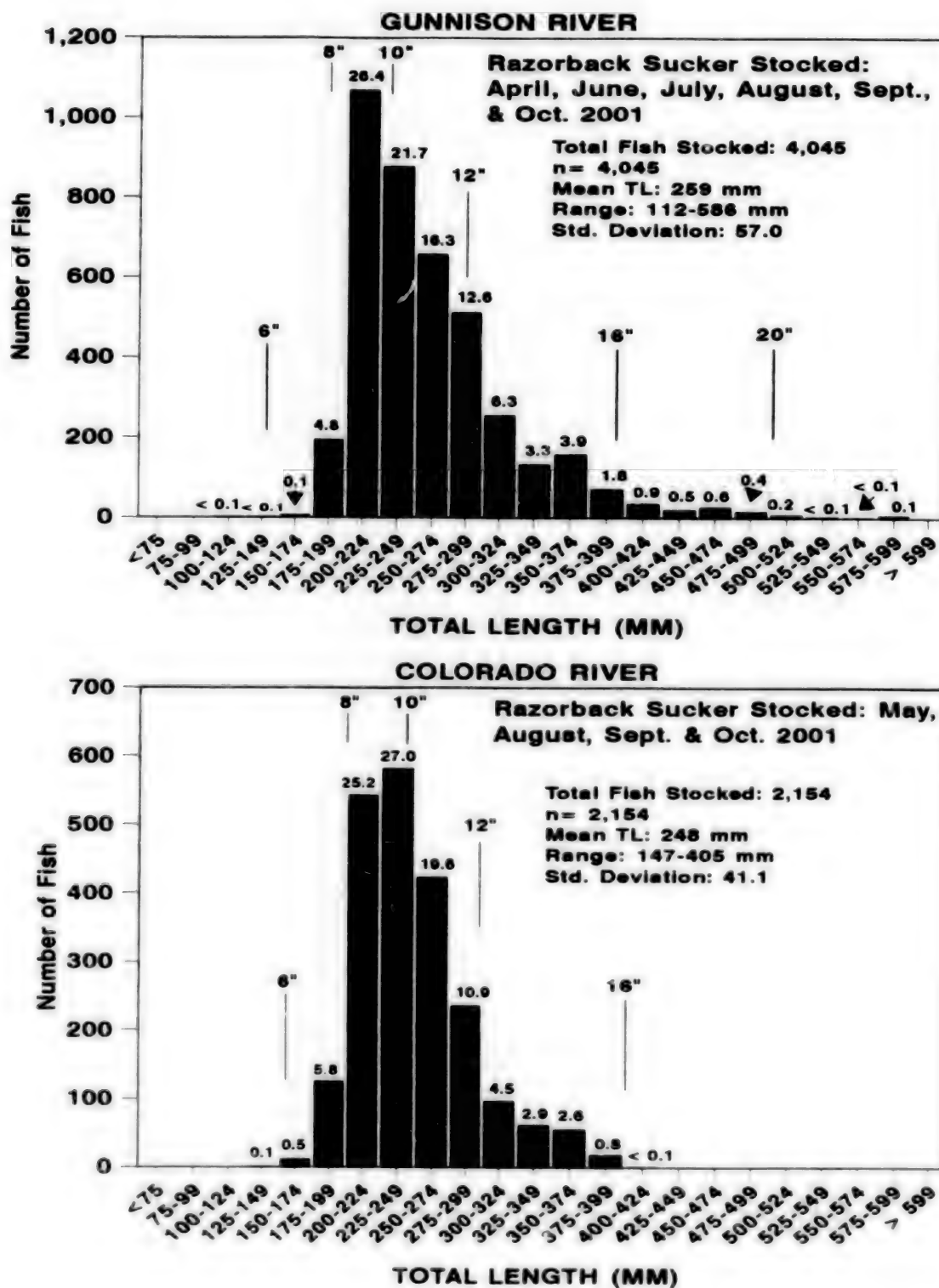


Figure C.7. Length-frequency distribution of razorback sucker stocked into the Gunnison (top) and Colorado (bottom) rivers during 2001. Note: numbers above the bars represent percent.

APPENDIX D

**Summary Statistics for Stocked Razorback Sucker
that were Subsequently Recaptured from 1997–2001**

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Table D.1. Summary statistics of razorback sucker stocked in the Gunnison (GU) and Colorado (CO) rivers between October 1995 and November 2000 that were subsequently recaptured during 1997, 1998, 1999, 2000, and 2001. Note RMI= river miles. Razorback sucker included in this table were fish that had been at large 6 months or greater following stocking.

Fish No.	Year Class/ Lot No.	Date Stocked	Date Recaptured	Time @ Large (mo.)	Length (mm) @ Release	Length (mm) @ Recapture	River/ RMI		River/ RMI		Displacement (RM) From Stocking	
							Stocked	Recaptured	Stocked	Recaptured	Upstrm	Downstrm
Year: 1997												
4F32	1992/1C	10/04/96	08/26/97	10.5	313	326	GU 57.0	GU 15.1				41.9
7771	1992/2B	10/04/96	10/02/97	11.7	370	388	GU 57.0	GU 40.0				17.0
Year: 1998												
0114	1996/11	09/15/97	05/04/98	7.7	322	333	GU 57.0	CO 107.6				120.4
1C20	1996/1A	09/15/97	05/07/98	7.8	247	262	GU 57.0	CO 67.2				160.8
6E6C	1996/1A	09/15/97	05/14/98	8.1	311	312	GU 57.0	CO 66.4				161.6
3925	1992/2A	10/04/96	05/22/98	19.2	355	407	GU 57.0	CO 158.6				69.4
5055	1992/2A	10/04/96	05/27/98	19.4	362	385	GU 57.0	CO 75.0				153.0
4F60	1992/1A	10/04/96	07/09/98	20.7	370	395	GU 57.0	CO 164.5				63.5
0A71	1995/12	09/25/97	07/15/98	9.5	399	436	GU 57.0	CO 108.8				119.2
755B	1995/20	09/25/97	08/05/98	10.1	399	432	GU 57.0	GU 24.8				32.2
3E23	1995/20	09/25/97	08/27/98	10.8	399	467	GU 57.0	GU 29.8				27.2
6329	1992/2B	10/04/96	09/09/98	22.7	332	363	GU 57.0	GU 26.5				30.5
Year: 1999												
4507	1992/2A	10/04/96	03/30/99	30.3	377	416	GU 57.0	CO 168.0				60.0
1516	1995/20	09/25/97	05/10/99	19.1	399	420	GU 57.0	GU 2.9				54.1
1E5E	1995/19	10/29/98	07/13/99	8.3	440	457	GU 57.0	CO 152.7				75.3
7138	1995/11	10/29/98	07/26/99	8.7	453	455	GU 57.0	GU 53.1				3.9
4C63	1995/20	10/29/98	09/14/99	10.3	417	439	GU 57.0	GU 27.9				29.1
061B	1995/11	10/29/98	09/16/99	10.4	412	405??	GU 57.0	GU 6.8				50.2
4E53	1995/13	10/29/98	09/16/99	10.4	439	453	GU 57.0	GU 4.9				52.1

Table D.1. (cont'd).

Fish No.	Year Class/ Lot No.	Date Stocked	Date Recaptured	Time @ Large (mo.)	Length (mm) @ Release	Length (mm) @ Recapture	River/ RMI		Displacement (RM) From Stocking	
							Stocked	Recaptured	Upstrm	Downstrm
Year: 2000										
1232	1998/09	10/29/99	05/04/00	6.0	235	235	CO 227.0	CO 158.3		68.7
4526	1995/21	05/10/99	03/08/00	9.7	???	460	GU 57.0	CO 158.3		69.7
7721	1998/01	11/04/99	05/10/00	6.0	194	196	GU 57.0	CO 164.9		63.1
2466	1998/01	11/04/99	05/10/00	6.0	129	132	GU 57.0	CO 164.9		63.1
301A	1998/03	09/22/99	03/28/00	6.0	205	210	CO 227.0	CO 164.9		62.1
326B	1998/03	09/22/99	04/05/00	6.3	179	192	CO 227.0	CO 169.1		57.9
0B49	1998/01	11/04/99	05/10/00	6.0	222	237	GU 57.0	CO 154.1		73.9
0F58 ^a	1998/01	11/04/99	05/10/00	6.0	272	297	GU 57.0	CO 154.1		73.9
4D14	1998/01	09/24/99	05/03/00	7.1	247	264	CO 227.0	CO 168.7		58.3
3959	1992/2A	10/04/96	05/03/00	42.1	339	416	GU 57.0	CO 168.6		59.4
2429	1998/01	11/04/99	05/10/00	6.0	233	277	GU 57.0	CO 162.8		65.2
4311	1998/01	11/04/99	05/10/00	6.0	219	245	GU 57.0	CO 162.8		65.2
1A74	1998/01	11/04/99	05/10/00	6.0	208	235	GU 57.0	CO 162.8		65.2
074D	1998/01	11/04/99	05/10/00	6.0	209	232	GU 57.0	CO 162.8		65.2
3363	1998/01	09/24/99	05/10/00	7.4	265	270	CO 227.0	CO 168.3		58.7
4D3D	1998/01	11/04/99	05/10/00	6.0	220	255	GU 57.0	CO 162.8		65.2
7310	1998/01	11/04/99	05/10/00	6.0	261	276	GU 57.0	CO 146.2		81.8
4C7B	1999/08	04/21/99	05/18/00	12.6	185	220	CO 220.9	CO 170.7		44.2
6D61	1992/3A	10/04/96	05/18/00	42.6	383	474	GU 57.0	GR 88.9 ^b	88.9	228.0
5C2F	1998/01	11/04/99	05/25/00	6.5	214	251	GU 57.0	CO 22.7		205.3
3A66	1998/01	09/24/99	05/25/00	7.8	197	232	CO 227.0	CO 154.1		72.9
363E ^c	1992/2A	10/04/96	06/05/00	43.7	387	475	GU 57.0	CO 163.6		64.4
1877	1995/07	10/29/98	06/07/00	18.9	411	431	GU 57.0	CO 174.4	3.4	57.0
0F58 ^a	1998/01	11/04/98	06/08/00	18.7	272	313	GU 57.0	CO 154.1		73.9

^a Multiple recaptures: captured again in 2000 (06/08) and again in 2001 (07/26).^b GR=Green River^c Captured again in 2001 (05/23).

Table D.1. (cont'd).

Fish No.	Year Class/ Lot No.	Date Stocked	Date Recaptured	Time @ Large (mo.)	Length (mm) @ Release	Length (mm) @ Recapture	River/ RMI		River/ RMI		Displacement (RM) From Stocking	
							Stocked	Recaptured	Stocked	Recaptured	Upstrm	Downstrm
Year: 2000 (cont'd)												
0D16	1998/01	09/24/99	06/08/00	8.3	219	247	GU 57.0	CO 154.1				73.9
1D25	1998/09	09/09/99	06/08/00	8.8	191	237	CO 227.0	CO 154.1				72.9
3959	1992/2A	10/04/96	06/08/00	43.8	339	427	GU 57.0	CO 154.1				73.9
4B1F	1995/20	10/29/98	08/04/00	20.8	445	458	GU 57.0	GU 5.8				51.2
331E	1996/1A	09/17/97	08/03/00	33.9	339	539	GU 57.0	GU 20.9				36.1
6613	1992/2A	10/04/96	09/05/00	46.6	325	439	GU 57.0	GU 50.3				6.7
Year: 2001												
3D23 ^d	1992/2A	04/03/01	10/06/01	6.0	???	463	GU 57.0	GU 3.0				54.0
2B13	1992/2A	10/04/96	06/29/01	55.7	311	395	GU 57.0	GU 3.0				54.0
2B4A	1998/01	11/04/99	09/05/01	22.5	237	390	GU 57.0	GU 40.7				16.3
2872	1998/01	11/04/99	05/30/01	17.5	231	393	GU 57.0	CO 163.6				64.4
184C	1998/01	11/04/99	05/08/01	16.8	242	378	GU 57.0	CO 101.5				126.5
0F58 ^a	1998/01	11/04/99	07/26/01	19.3	272	412	GU 57.0	CO 131.1				96.9
3742	1999/10	09/19/00	05/11/01	7.5	207	223	CO 220.9	CO 175.5				45.4
4C10	1999/11	10/26/00	06/07/01	7.2	208	235	CO 177.4	CO 175.5				1.9
3713	1999/01	10/30/00	05/10/01	6.2	176	199	CO 177.4	CO 167.8				9.6
0A1E	1999/11	09/12/00	05/10/01	8.1	220	255	CO 177.4	CO 167.8				9.6
2B72	1999/08	11/09/00	05/31/01	6.2	240	290	CO 177.4	CO 163.6				13.8
5120	1999/11	09/12/00	06/06/01	8.6	215	245	CO 177.4	CO 175.6				1.8
300A	1999/11	09/12/00	05/15/01	7.9	198	221	CO 177.4	CO 175.6				1.8
2724	1999/11	10/27/00	05/02/01	6.0	211	227	CO 177.4	CO 175.6				1.8
5161	1999/11	10/27/00	06/05/01	7.1	196	221	CO 177.4	CO 158.6				18.8
0B5F	1999/11	10/27/00	05/10/01	6.3	196	221	CO 177.4	CO 167.8				9.6
6510	1999/11	09/11/00	05/10/01	7.8	204	215	CO 177.4	CO 167.8				9.6
2659	1999/11	09/11/00	07/19/01	10.1	195	277	CO 177.4	CO 173.6				3.8

^d also captured on 09/05/2001.

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Table D.1. (cont'd).

Fish No.	Year Class/ Lot No.	Date Stocked	Date Recaptured	Time @ Large (mo.)	Length (mm) @ Release	Length (mm) @ Recapture	River/ RMI Stocked	River/ RMI Recaptured	Displacement (RM) From Stocking	
									Upstrm	Downstrm
Year: 2001 (cont'd)										
7956	1999/11	10/27/00	06/06/01	7.1	235	273	CO 177.4	CO 175.6		1.8
4205	1999/11	09/11/00	05/11/01	7.8	211	243	CO 177.4	CO 175.8		1.6
3147	1999/11	09/11/00	10/04/01	12.5	226	342	CO 177.4	CO 175.5		0
5438	1999/11	09/11/00	06/07/01	8.6	201	230	CO 177.4	CO 175.5		1.9
5043	1999/11	10/26/00	05/15/01	6.5	216	235	CO 177.4	CO 175.7		1.7
793C	1999/11	10/26/00	06/07/01	7.2	197	221	CO 177.4	CO 175.5		1.9
0803	1999/11	10/27/00	05/15/01	6.5	195	222	CO 177.4	CO 175.6		1.8
037E	1999/11	09/11/00	10/04/01	12.5	242	340	CO 177.4	CO 177.4		0
2C01	1999/10	09/19/00	06/21/01	8.9	194	215	CO 220.9	CO 155.9		65.0
7314	1999/11	09/11/00	04/09/01	6.8	300	325	CO 177.4	CO 176.3		1.1
OC6D	1999/10	09/19/00	05/29/01	8.1	266	309	CO 229.9	CO 154.1		75.8
5D79	1999/11	09/11/00	09/20/01	12.0	240	389	CO 177.4	CO 177.4		0
0539	1999/11	09/11/00	09/20/01	12.0	205	342	CO 177.4	CO 177.4		0
363E ^c	1992/2A	10/04/96	05/23/01	54.5	382	493	GU 57.0	CO 154.1		73.9
5D60	1992/2A	10/04/96	08/06/01	56.9	314	458	GU 57.0	GU 3.0		54.0
714F	1991	06/12/00	08/07/01	13.6	508	508	GU 57.0	GU 17.9	14.9	39.1
770B	1992/2B	10/04/96	09/04/01	57.9	389	415	GU 57.0	GU 50.2		6.8

^c also captured on 06/05/2000.

APPENDIX E

**Family Lots and Year-Classes Represented for all Razorback Sucker
Recaptured and for Those Fish that had been at Large
for 6 Months or more Following Stocking**

Table E.1 Number and percentage of all razorback sucker (RZ) that were recaptured following stocking between 1997 and 2001 from the various year classes and family lots stocked in the Colorado and Gunnison rivers. Razorback sucker listed in the table were stocked from 1994–2000.

Year Class	Family Lot No.	Dates Stocked	No. of RZ Stocked	Mean TL (mm) Stocked	No. of RZ Recaptured	Percent Recaptured
1991	1991/GR ^a	06/12/01	2	504	1	50.0
1992	1992/1A	10/04/96	30	344	1	3.3
	1992/1C	10/04/96	41	339	1	2.4
	1992/2A	10/04/96	89	342	12	13.5
	1992/2B	10/04/96	57	355	3	5.3
	1992/3A	10/04/96	58	333	1	1.7
1995	1995/07	09/25/97	13	399 ^b	0	--
		10/29/98	9		1	11.9
	1995/11	09/25/97	45		4	--
		10/29/98	9		2	22.2
	1995/12	09/25/97	7		5	71.4
	1995/13	10/29/98	9	408	1	11.1
	1995/16	09/25/97	4		2	50.0
	1995/18	10/29/98	6		1	16.7
		05/10/99	3		0	--
		06/12/01	3		1	33.3
	1995/19	09/25/97	48	399 ^b	1	2.1
		10/29/98	9		1	11.1
	1995/20	09/25/97	58		5	8.6
		10/29/98	9		2	22.2
	1995/21	09/25/97	1		0	--
		05/10/99	3	???	1	33.3
		06/21/01	3	463	1	33.3
1996	1996/01A	09/12/97	68	???	0	--
		09/15/97	423	239	8	1.9
		09/17/97	80	230	1	1.3
		09/26/97	21	196	0	--
		10/14/97	2	???	0	--

^a GR=Green River.

^b mean total length at stocking was determined from 30 representative razorback sucker.

Table E.1. (cont'd).

Year Class	Family Lot No.	Dates Stocked	No. of RZ Stocked	Mean TL (mm) Stocked	No. of RZ Recaptured	Percent Recaptured
1996	1996/01C	10/04/96	41	339	1	2.4
	1996/1A	10/04/96	30	344	5	16.7
	1996/2A	10/04/96	89	342	2	2.2
	1996/2B	10/04/96	57	349	2	3.5
	1996/03A	09/12/97	504	157	0	--
		09/15/97	305	206	1	0.3
		09/17/97	196	205	0	--
		10/14/97	31	192	0	--
	1996/11	09/15/97	40	279	1	2.5
		09/17/97	495	280	0	--
1997	1997/02	06/23/98	121	213	3	2.5
		09/01/98	147	220	0	--
1998	1998/01	09/24/99	274	211	4	1.5
		10/02/99	53	210	0	--
		10/29/99	46	212	0	--
		11/04/99	455	211	16	3.5
1998	1998/03	08/03/99	289	190	0	--
		08/04/99	150	196	0	--
		08/05/99	706	174	0	--
		08/06/99	323	173	0	--
		08/10/99	268	172	0	--
		09/22/99	1,539	169	2	0.1
		10/26/99	707	175	0	--
		08/22/01	147	310	1	0.7
	1998/09	09/08/99	224	185	0	--
		09/09/99	211	178	0	--
		09/10/99	120	173	0	--
		10/29/99	723	155	1	0.1
1999	1999/01	09/07/00	300	127	2	0.7
		10/30/00	450	205	1	0.2
		10/31/00	46	212	0	--
		11/01/00	38	186	0	--
		11/20/00	194	135	0	--

Table E.1. (cont'd).

Year Class	Family Lot No.	Dates Stocked	No. of RZ Stocked	Mean TL (mm) Stocked	No. of RZ Recaptured	Percent Recaptured
1999	1999/05	09/07/00	409	121	4	1.0
		11/09/00	39	219	0	--
	1999/07	08/23/00	130	177	0	--
		08/24/00	108	175	0	--
		08/25/00	37	182	0	--
		09/07/00	501	123	4	--
	1999/08	04/19/00	427	127	0	--
		04/21/00	712	126	4	0.6
		11/07/00	247	198	0	--
		11/09/00	57	214	2	3.5
	1999/10	09/19/00	1,538	211	3	0.2
		09/20/00	877	205	1	0.1
		09/21/00	463	197	1	0.2
		09/22/00	246	197	0	--
	1999/11	04/15/00	1,200	117	0	--
		08/24/00	1,011	208	1	< 0.1
		08/25/00	381	213	1	0.3
		09/07/00	1,052	124	15	1.4
		09/11/00	1,269	227	9	0.7
		09/12/00	523	225	4	0.8
		09/13/00	332	223	0	--
		10/26/00	339	208	3	0.9
		10/27/00	319	211	5	1.6
		10/30/00	180	213	0	--
		10/31/00	198	168	0	--
		11/03/00	478	216	0	--
	1999/13	09/07/00	869	116	2	0.2
		11/20/00	378	???	0	--
	1999/14	09/07/00	462	119	1	0.2
		10/31/00	822	147	0	--
		11/20/00	1,139	137	0	--

Table E.1. (cont'd).

<u>Year</u> <u>Class</u>	<u>Family</u> <u>Lot No.</u>	<u>Dates</u> <u>Stocked</u>	<u>No. of RZ</u> <u>Stocked</u>	<u>Mean TL (mm)</u> <u>Stocked</u>	<u>No. of RZ</u> <u>Recaptured</u>	<u>Percent</u> <u>Recaptured</u>
1999	1999/22	09/07/00	779	123	6	0.8
		11/20/00	347	???	0	--
1999	1999/26	09/07/00	1,105	122	6	0.5
		10/31/00	727	141	0	--
		11/20/00	649	???	0	--
	1999/27	09/07/00	853	127	9	1.1
		11/02/00	331	241	0	--
		11/09/00	29	225	0	--
	1999/29	04/21/00	1,330	124	2	0.2
		10/12/00	440	159	0	--
		10/31/00	378	139	0	--
		11/20/00	581	133	0	--

Table E.2 Number and percentage of 84 razorback sucker (RZ) that were recaptured 6 months or greater following stocking between 1997 and 2001 from the various year classes and family lots stocked in the Colorado and Gunnison rivers. Razorback sucker listed in the table were stocked from 1994–2000.

Year Class	Family Lot No.	Dates Stocked	No. of RZ Stocked	Mean TL (mm) Stocked	For RZ	
					@ Large for ≥ 6 months	
					No. of RZ Recaptured	Percent Recaptured
1991	1991/GR ^a	06/12/01	2	504	1	50.0
1992	1992/1A	10/04/96	30	344	1	3.3
	1992/1C	10/04/96	41	339	1	2.4
	1992/2A	10/04/96	89	342	11	12.4
	1992/2B	10/04/96	57	355	3	5.3
	1992/3A	10/04/96	58	333	1	1.7
1995	1995/07	09/25/97	13	399 ^b	0	--
		10/29/98	9		1	11.9
	1995/11	09/25/97	45		0	--
		10/29/98	9		2	22.2
	1995/12	09/25/97	7		1	14.2
	1995/13	10/29/98	9		1	11.1
	1995/19	09/25/97	48		0	--
		10/29/98	9		1	11.1
	1995/20	09/25/97	58		3	5.2
		10/29/98	9		2	22.2
	1995/21	09/25/97	1		0	--
		05/10/99	3		1	33.3
1996	1996/1A	09/12/97	68	???	0	--
		09/15/97	423	239	2	0.5
		09/17/97	80	230	1	0.3
		09/26/97	21	196	0	--
	1996/11	09/15/97	40	279	1	2.5
		09/17/97	495	280	0	--
1998	1998/01	09/24/99	274	211	4	1.5
		10/02/99	53	210	0	--
		10/29/99	46	212	0	--
		11/04/99	455	211	16	3.5

^a GR=Green River.

^b mean total length at stocking was determined from 30 representative razorback sucker.

Table E.2. (cont'd).

Year Class	Family Lot No.	Dates Stocked	No. of RZ Stocked	Mean TL (mm) Stocked	For RZ @ Large for ≥ 6 months	
					No. of RZ Recaptured	Percent Recaptured
1998	1998/03	08/03/99	289	190	0	--
		08/04/99	150	196	0	--
		08/05/99	706	174	0	--
		08/06/99	323	173	0	--
		08/10/99	268	172	0	--
		09/22/99	1,539	169	2	0.1
	1998/09	10/26/99	707	175	0	--
		09/08/99	224	185	0	--
		09/09/99	211	178	1	0.9
		09/10/99	120	173	0	--
		10/29/99	723	155	1	0.1
1999	1999/01	09/07/00	300	127	0	--
		10/30/00	450	205	1	0.2
		10/31/00	46	212	0	--
		11/01/00	38	186	0	--
		11/20/00	194	135	0	--
	1999/08	04/19/00	427	127	0	--
		04/21/00	712	126	1	0.1
		11/07/00	247	198	0	--
		11/09/00	57	214	1	1.8
	1999/10	09/19/00	1,538	211	3	0.2
		09/20/00	877	205	0	--
		09/21/00	463	197	0	--
		09/22/00	246	197	0	--
	1999/11	04/15/00	1,200	117	0	--
		08/24/00	1,011	208	0	--
		08/25/00	381	213	0	--
		09/07/00	1,052	124	0	--
		09/11/00	1,269	227	9	0.7
		09/12/00	523	225	3	0.6
		09/13/00	332	223	0	--
		10/26/00	339	208	3	0.9
		10/27/00	319	211	5	1.6
		10/30/00	180	213	0	--
		10/31/00	198	168	0	--
		11/03/00	478	216	0	--

APPENDIX F
Annual Up- and Downstream Displacement Distances
for Stocked Razorback Sucker: 1996–2001

Table F.1. Upstream and downstream displacement (river miles [RM])^a data for all length sizes of domestic-reared razorback sucker (RZ) between stocking and recapture in the Colorado and Gunnison rivers by individual year between 1996 and 2001. The data were partitioned for razorback sucker that had been at large for less than 6 months and for fish at large 6 months or more following stocking.

Year: 1996				
	<u>@ Large for < 6 months</u>		<u>@ Large for ≥ 6 months</u>	
	<u>Dnstrm</u>	<u>Upstrm</u>	<u>Dnstrm</u>	<u>Upstrm</u>
No. of RZ ^b	7		0	
Mean				
Displacement (RM)	4.3 (7) ^c	-- (0) ^c	--	--
Range (RM)	0.2-10.9	--	--	--
Duration	3 days - 4 days		--	
Year: 1997				
	<u>@ Large for < 6 months</u>		<u>@ Large for ≥ 6 months</u>	
	<u>Dnstrm</u>	<u>Upstrm</u>	<u>Dnstrm</u>	<u>Upstrm</u>
No. of RZ ^b	15		2	
Mean				
Displacement (RM)	15.4 (13) ^c	0.03 (2) ^c	29.5 (2) ^c	-- (0) ^c
Range (RM)	0.1-39.6	0.1-0.4	17.0-41.9	--
Duration	5 days - 31 days		10.5 months-11.7 months	
Year: 1998				
	<u>@ Large for < 6 months</u>		<u>@ Large for ≥ 6 months</u>	
	<u>Dnstrm</u>	<u>Upstrm</u>	<u>Dnstrm</u>	<u>Upstrm</u>
No. of RZ ^b	4		10	
Mean				
Displacement (RM)	38.4 (4) ^c	-- (0) ^c	100.0 (10) ^c	-- (0) ^c
Range (RM)	27.5-49.8	--	27.2-161.6	--
Duration	43 days - 45 days		6.8 months-20.7 months	
Year: 1999				
	<u>@ Large for < 6 months</u>		<u>@ Large for ≥ 6 months</u>	
	<u>Dnstrm</u>	<u>Upstrm</u>	<u>Dnstrm</u>	<u>Upstrm</u>
No. of RZ ^b	14		7	
Mean				
Displacement (RM)	59.7 (14) ^c	-- (0) ^c	46.4 (7) ^c	-- (0) ^c
Range (RM)	47.9-88.1	--	3.9-75.3	--
Duration	13 days - 37 days		8.3 months-29.3 months	

Table F.1. (cont'd).

Year: 2000				
	<u>@ Large for < 6 months</u>		<u>@ Large for ≥ 6 months</u>	
	<u>Dnstrm</u>	<u>Upstrm</u>	<u>Dnstrm</u>	<u>Upstrm</u>
No. of RZ ^b	76		30	
Mean				
Displacement (RM)	17.1 (76) ^c	-- (0) ^c	75.7 (30) ^c	46.2 (2) ^c
Range (RM)	0.2–103.8	--	6.7–228.0	3.4–88.9
Duration	1 day - 127 days		6 months–46.6 months	
Year: 2001				
	<u>@ Large for < 6 months</u>		<u>@ Large for ≥ 6 months</u>	
	<u>Dnstrm</u>	<u>Upstrm</u>	<u>Dnstrm</u>	<u>Upstrm</u>
No. of RZ ^b	15		34	
Mean				
Displacement (RM)	23.1 (15) ^c	-- (0) ^c	24.8 (34) ^c	1.4 (2) ^c
Range (RM)	1.5–75.8	--	0–126.5	0–31.3
Duration	14 days - 97 days		6 months–57.9 months	

^a displacement is defined as the maximum distance moved (river miles) by a razorback sucker. between the stocking site and recapture location, either upstream or downstream.

^b the number of razorback sucker that potentially moved up- or downstream between stocking and recapture.

^c the number of razorback sucker that actually exhibited up- or downstream movement between stocking and recapture is in parenthesis.



END

10-21-03